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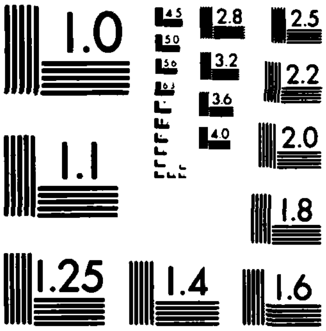

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In-House Report
September 1984

MC68CRX CROSS-ASSEMBLER USERS MANUAL

Ken D. Romano

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ROME AIR DEVELOPMENT CENTER
Air Force Systems Command
Griffiss Air Force Base, NY 13441

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APPROVED: Thadeus J Domurat

THADEUS J. DOMURAT
Chief, Signal Intelligence Branch
Intelligence & Reconnaissance Division

APPROVED: Thadeus J Domurat

THADEUS J. DOMURAT
Acting Chief, Intelligence & Reconnaissance Division

FOR THE COMMANDER: Donald A Brantingham

DONALD A. BRANTINGHAM
Plans Office

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This in-house report is a technical user's manual containing all the information needed to utilize a Fortran Cross-Assembler (MC68CRX) for the Motorola MC68000 microprocessor. The Cross-Assembler was developed in-house at RADC (IRAP). A program listing (Fortran 77) is also included, along with information concerning hardware connections from the MC68000 to a DEC mainframe computer.

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INTRODUCTION

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This manual describes the MC68CRX cross-assembler and a fortran transfer program, which were developed to facilitate programming of the Motorola MC68000 microprocessor, and development of MC68000 based systems. Both programs are written in Fortran 77, which allows the user to utilize the features of a mainframe computer, such as the DEC 11/70 or DEC 11/45. The cross-assembler translates MC68000 assembly language code into machine language. The transfer program downloads the machine code to the MC68000.

This manual is designed as a reference to the specifics of the cross-assembler and transfer program, and assumes that the user is familiar with MC68000 assembly language and the host system. For detailed information on MC68000 machine code, the user is encouraged to consult the sources listed in APPENDIX B.

A complete listing of the cross-assembler and transfer program is included in APPENDIX A.

RE: Legibility, Appendix A
Best copy available per Ms. Joyce Watkins,
RADC/TSR

MC68CRX USERS MANUAL TABLE OF CONTENTS

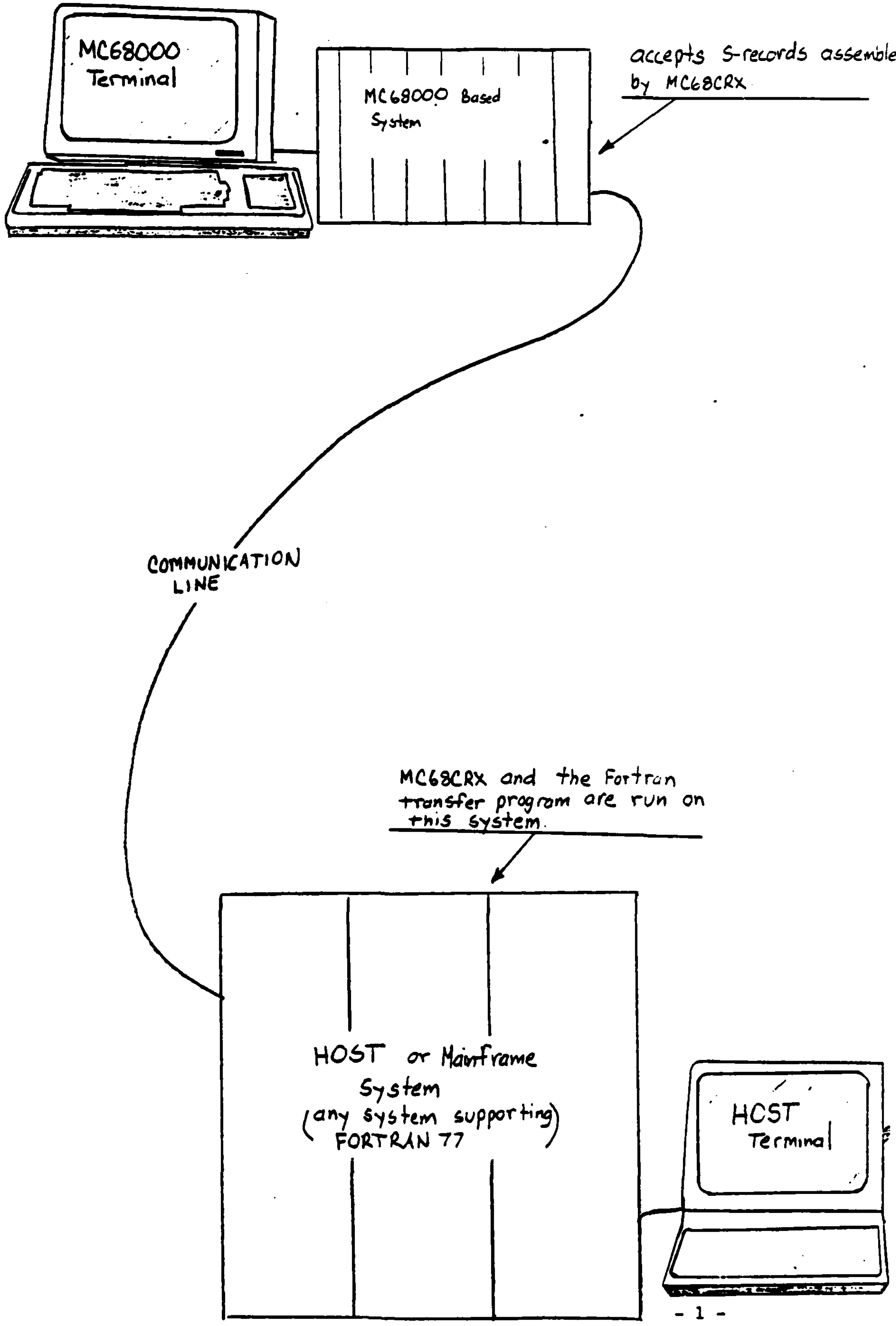
Section page

ASSEMBLER MNEMONICS

DIRECTIVES

OPERATIONS

SYSTEM DIAGRAM


MC68000 Terminal
MC68000 Based System
accepts S-records assembled by MC68CRX
COMMUNICATION LINE
MC68CRX and the Fortran transfer program are run on this system.
HOST or Mainframe System (any system supporting FORTRAN 77)
HCST Terminal

I. RUNNING THE CROSS ASSEMBLER:

Begin by typing (on the host terminal):
RUN MC68CRX
program prompt: INPUT MEMORY LOCATION (HEX) AT WHICH TO BEGIN PROGRAM STORAGE IN MC68000 RAM (<8000,>06FF)
user input: four character hex string, which will be the program's starting address.

program prompt: INPUT MEMORY LOCATION (HEX) AT WHICH TO BEGIN DATA STORAGE IN MC68000 RAM
user input: four character hex string, which will be the starting address for data storage.

program prompt: INPUT NAME OF ASSEMBLER CODE FILE
user input: name of file containing assembler code.

program prompt: INPUT NAME OF OUTPUT (S RECORD) FILE TO BE CREATED: XXXXX.M68
user input: name of file which will contain assembled S records, to be sent to the MC68000. 5 letters.M68.

program prompt: INPUT NAME OF LIST FILE TO BE CREATED: XXXXX.LST
user input: name of file which will contain assembler code and its assembled hex code, useful for debugging.

II. TRANSFER OF S RECORDS TO THE MC68000

With MAXbug firmware monitor:

After the MC68CRX program has been run, the S record file (FNAME.M68) must be sent to the MC68000 using the MC68000 TRANSFER PROGRAM in file TRANSFER.FTN. This program should be taskbuilt with logical unit number 1 being assigned to the MC68000 terminal, and number 5 being the terminal being used on the host system.

user input on the host terminal: RUN TRANSFER
user input on the MC68000 terminal: RE;=FNAME or RE;X=FNAME
with the X option, S records will be displayed on the MC68000 terminal as they arrive.
prompt on host terminal: ENTER VERIFY;=FNAME OR *DONE ON MC68000 TERMINAL
user input on MC68000 terminal: VERIFY;=FNAME or *DONE

*DONE completes the transfer process, VERIFY;=FNAME checks the S records again and displays any discrepencies, will cause a prompt of : ENTER VERIFY;=FNAME OR *DONE ON MC68000 TERMINAL on the host terminal again.

With VMEbug firmware monitor:

Use LO;=FNAME (load) instead of RE;=FNAME.

III. TRANSFER OF S-RECORDS USING A SINGLE TERMINAL

If the transfer program is taskbuilt with logical unit numbers 1 and 5 being assigned to the MC68000, transfer of S records can be done without using a terminal on the host system.

user input on the MC68000 terminal:

```
                    *HEL (account number)
                         *(password)
                        *RUN TRANSFER
                   RE;=FNAME or RE;X=FNAME
                    VERIFY;=FNAME or *DONE
               (if previous command was verify,
                       now type *DONE)
                            *BYE
```

With VMEbug firmware monitor:

Use LO;=FNAME instead of RE;=FNAME

IV. RUNNING PROGRAMS ON THE MC68000

With MAXbug firmware monitor.

After the S records have been sent to the MC68000, the program can be run with the following commands:

user input on MC68000 terminal: PC xxxx , where xxxx is the program's starting address in hex. (Same as the program storage location on page 2)

G TILL yyyy , where yyyy is the address of the last assembler instruction, this can be obtained from the list file.

(for more details concerning running programs on the MC68000, consult: Motorola MC68000 DESIGN MODULE USER'S GUIDE [MEX68KDM(D3)] (MAXbug firmware) or VMEbug DEBUGGING PACKAGES USERS MANUAL [MVMEBUG/D2].)

With VMEbug firmware monitor.

Use .PC instead of PC, GT instead of G TILL.

THE ASSEMBLER CODE FILE

Programs in MC68000 assembly language must be contained in a file of 100 lines or less on the host system. Long programs can be broken into parts and put into memory in the proper order, remembering that jumps to labels in different sections will have to be modified.

The assembler code file is made up of 4 distinct fields. Each field starts in a column which is unique to the field. The four fields are LABEL, OPERAT, ADRES1, ADRES2 and have the following functions:

LABEL : columns 1-5, can be used to label lines, constants, or provide jump-to points in the program.

OPERAT : columns 20-25, contains the assembler operation or directive.

ADRES1 : columns 40-48, contains the source address or immediate data.

ADRES2 : columns 50-58, contains the destination address.

EXAMPLE FILE:

```
ABSO               EORIW               #$FFFF     D0
                   SWAP                D0
                   EORIW               #$FFFF     D0
                   SWAP                D0
                   ADD1L               #1         D0
POSTIV             ADD1L               D0         D1
                   SUB1W               #1         D2
                   CMPIW               #0         D2
                   BGT                 (VARIAT
                   DIVU                #1         D1
                   MULU                #100       D1
                   DIVU                $7F02      D1
                   MOVEW               D1         $7F08
                   MOVEAW              $7EFC      A0
                   MOVEW               D1         #A0
                   ADDQW               #2         $7EFC
                   CMPIW               #$74D0     $7EFC
                   BEQ                 (STOP
                   MOVEW               #0         $7F00
                   RTS
STOP               STOP
                   END
```

ADDRESSING MODES:

The MC68CRX cross-assembler supports nine of the twelve addressing modes available on the MC68000. The user specifies which mode is being used by the first one or two characters in the source (ADRES1) and destination (ADRES2) fields.

ADDRESSING MODE	assembler code file source/dest. field	Motorola RTL notation
Data register direct	Dn	Dn
Address register direct	An	An
Address register indirect	@An	@An
Postincrement register indirect	+An	An+
Predecrement register indirect	-An	An-
Register indirect with integer displacement	%IIIIIAn or %-IIIIIAn	An(d)
Register indirect with hex displacement	%$HHHHAn	An(d)
Program counter relative with integer displacement	PCIIIII or PC-IIIII	PC(d)
Program counter relative with hex displacement	PC$HHHH	PC(d)
Immediate integer	#I or #II...#IIIII	#xxxx
Immediate hex	#$HHHH	#xxxx
Absolute short	$HHHH or (label	xxx.W

NOTES: n = register number
IIIII = 5 place integer
HHHH = 4 place hex

ADDRESSING MODE DETAILS:

Data Register Direct - Dn

The operand is stored in data register n.

Address Register Direct -@An

The operand is stored in address register n.

Address Register Indirect - An

The operand is stored in the memory location which is stored in address register n.

Postincrement Register Indirect - +An

The operand is stored in the memory location which is stored in address register n. After the instruction is executed, the location stored in An is incremented by 1,2, or 4, depending on the operation data size.

Predecrement Register Indirect - -An

Same as Postincrement register indirect, except that the location stored in An is decremented by 1,2, or 4, before the operation is executed.

Register Indirect With Displacement - %(displacement)An

The operand is stored in the location stored in An plus the displacement.

Program Counter Relative With Displacement - PC(displacement)

The location of the operand is the sum of the program counter and the displacement.

Immediate - #(data)

The operand is '(data)', either hex or integer.

Absolute Short - $(location) or (label

The operand is stored in memory location '(location)', or the location associated with 'label'.

NON-ASSEMBLY LANGUAGE COMMANDS: DIRECTIVES

Since the user specifies the memory locations where data and program storage are to begin, the need for an origin (ORG) command is eliminated. However, some useful data storage directives are supported by the assembler. These include DC, DS and EQU which may be before, after or buried within the assembler source file and will have no effect on the program storage.

DIRECTIVE: DC - define constant

field	LABEL	OPERAT	ADRES1
(as would appear in assembly code file)	[label]	DCL	[-]constant
	[label]	DCW	([-]constant)('character')
	[label]	DCB	(constant)('character')

NOTE: [ ] - enclosed is optional

( ) - one of the enclosed types must be used

Stores the value in ADRES1 field in the next available data storage location. Automatically increments data count to assure word or long word data begins on an even memory location. Note that signed data is not allowed for DCB (byte storage). Data counter incremented by 2 for DCW (word storage), 4 for DCL (long word storage), 1 for DCB.

CALL STATEMENT IN MAIN PROGRAM:

```
CALL DC(LABEL, OPERAT, ADRES1, DCOUNT, NCK)
```

DIRECTIVE: EQU - equate

field	LABEL	OPERAT	ADRES1
	[label]	EQU	$HHHH

Equates label with memory location shown in ADRES1 field. Adds nothing to memory.

CALL STATEMENT IN MAIN PROGRAM:

```
CALL EQU(LABEL, ADRES1, NCK)
```

DIRECTIVE: DS - define storage space

field	LABEL	OPERAT	ADRES1
	[label]	DSL	
	[label]	DSW	
	[label]	DSB	

Keeps space open for data storage. Four bytes for DSL, two bytes for DSW, one byte for DSB.

CALL STATEMENT IN MAIN PROGRAM:

```
CALL DS(LABEL, OPERAT, DCOUNT, NCK)
```

DIRECTIVE: END - Ends assembler file.

field	LABEL	OPERAT
	[label]	END

ASSEMBLER OPERATIONS

OPERATION: ADD - add binary. Adds source (ADRES1) to destination (ADRES2) and stores in destination.

field	LABEL	OPERAT	ADRES1	ADRES2
	[label]	ADD1(B)(W)(L)	(source)	D(n)
	[label]	ADD2(B)(W)(L)	D(n)	(destination)

```
ADD1B - Data register is destination - byte data
    W -  "       "       "       "        - word data
    L -  "       "       "       "        - long word data

ADD2B - Data register is source - byte data
    W -  "       "       "     "    - word data
    L -  "       "       "     "    - long word data
```

ADDRESSING MODES SUPPORTED:

ADD1	ADD2
Source - all supported Destination - data register direct	Source - data register direct Destination - all except: address register indirect immediate PC relative with disp.

CALL STATEMENT IN MAIN PROGRAM:

```
     CALL ANDADD(LABEL, OPERAT, ADRES1, ADRES2, PCOUNT, NWORDS,
HEXM, BIN1, BIN2)
```

OPERATION: SUB - Subtract source (ADRES1) from destination (ADRES2) and stores result in destination.

field	LABEL	OPERAT	ADRES1	ADRES2
	[label]	SUB1(B)(W)(L)	(source)	D(n)
	[label]	SUB2(B)(W)(L)	D(n)	(destination)

SUB1B - data register destination - byte data

W - " " " - word data

L - " " " - long word data

SUB2B - data register source - byte data

W - " " " - word data

L - " " " - long word data

ADDRESSING MODES SUPPORTED:

SUB1

source - all
destination - data register direct

SUB2

source - data register direct
destination - all except:
data register direct
address " "
PC relative with disp.
immediate

CALL STATEMENT IN MAIN PROGRAM:

same as ADD

OPERATION: AND - Logical AND bit by bit between source (ADRES1) and destination (ADRES2), result stored in destination.

field	LABEL	OPERAT	ADRES1	ADRES2
	[label]	AND1(B)(W)(L)	(source)	D(n)
	[label]	AND2(B)(W)(L)	D(n)	(destination)

AND1B - Data register destination - byte data
W - " " " - word data
L - " " " - long word data

AND2B - Data register source - byte data
W - " " " - word data
L - " " " - long word data

ADDRESSING MODES SUPPORTED:

AND1

Source - all except:
  address register direct
Destination - data register direct

AND2

Source - data register direct
Destination - all except:
  address register direct
  immidiate
  PC relative with disp.

CALL STATEMENT IN MAIN PROGRAM:

CALL ANDADD(LABEL, OPERAT, ADRES1, ADRES2, PCOUNT, NWORDS, HEXM, BIN1, BIN2)

OPERATION: ORR - Inclusive OR bit by bit between source (ADRES1) and destination (ADRES2), stored in destination.

field	LABEL	OPERAT	ADRES1	ADRES2
	[label]	ORR1(B)(W)(L)	(source)	D(n)
	[label]	ORR2(B)(W)(L)	D(n)	(destination)

ORR1B - Data register destination - byte data
W - " " " - word data
L - " " " - long word data

ORR2B - Data register source - byte data
W - " " " - word data
L - " " " - long word data

For addressing mode details see AND.

CALL STATEMENT , same as AND.

OPERATION: MOVE - Move data from source (ADRES1) to destination (ADRES2).

field	LABEL	OPERAT	ADRES1	ADRES2
	[label]	MOVE(B)(W)(L) (specifies data size)	(source)	(destination)

ADDRESSING MODES SUPPORTED:

source - all except: PC relative with displacement

destination - all except: address register direct

immediate

PC relative with disp.

CALL STATEMENT IN MAIN PROGRAM:

CALL MOVE(LABEL, OPERAT, ADRES1, ADRES2, PCOUNT, NWORDS, HEXM, BIN1, BIN2, BIN3)

OPERATION: CMP - Subtract the source (ADRES1) operand from the destination (ADRES2) operand and set the condition codes according to result. Niether operand is changed.

field	LABEL	OPERAND	ADRES1	ADRES2
	[label]	CMP(B)(W)(L)	(source)	D(n)

CMPB - byte data

W - word data

L - long word data

ADDRESSING MODES SUPPORTED:

Source - All

Destination - data register direct

CALL STATEMENT IN MAIN PROGRAM:

CALL CMP(OPERAT)

CALL ANDADD(...)

OPERATION: EOR - Exclusive OR logical. Performs an exclusive or, bit by bit between the source (ADRES1) and destination (ADRES2), and stores the result in the destination operand.

field	LABEL	OPERAT	ADRES1	ADRES2
	[label]	EOR(B)(W)(L) (specifies data size)	D(n)	(destination)

DESTINATION ADDRESSING MODES ALLOWED:

all except:
- address register direct
- PC relative with displacement
- immediate

OPERATION: ASL, ASR - Arithmetic shift left, right. Arithmetically shifts contents of register or memory location by a specified number of bits.

field	LABEL	OPERAT	ADRES1	ADRES2
	[label]	ASLD(B)(W)(L)	D(n)	D(m)
	[label]	ASRD(B)(W)(L) (shifts contents of destination)	D(n) (contains number of bit shifts)	D(m) (data register to be shifted)
	[label]	ASLM	(address)	
	[label]	ASRM (shifts data in memory one bit)	(address) (address of data to be shifted)	

ADDRESSING SUPPORTED:

ASLD, ASRD : as shown above

```
ASLM, ASRM : address register indirect
             post increment register indirect
             predecrement      "        "
             register indirect with displacement
             absolute short
```

CALL STATEMENT IN MAIN PROGRAM:

```
    CALL AS(LABEL, OPERAT, ADRES1, ADRES2, PCOUNT, NWORDS,
HEXM, BIN1, BIN2)
```

OPERATION: LSL,LSR - Same as ASL, ASR, except LSR places a zero in the most significant bit of the operand, where ASR keeps it intact.

(See ASL, ASR for details on addressing and format of operation.)

OPERATION: ROL, ROR - Rotates data to the left or right by a specified number of bits.

field	LABEL	OPERAT	ADRES1	ADRES2
	[label]	ROLD(B)(W)(L)	D(n)	D(m)
	[label]	RORD(B)(W)(L)	D(n)	D(m)

(see ASL, ASR)

[label]	ROLM	(address)
[label]	RORM	(address)

ADDRESSING MODES SUPPORTED:

same as ASL, ASD

CALL STATEMENT IN MAIN PROGRAM:

CALL AS(LABEL, OPERAT, ADRES1, ADRES2, PCOUNT, HEXM, BIN1, BIN2)

OPERATION: Bcc - Conditional branch. cc is condition code. If condition is met, control is transferred to location specified by ADRES1.

field	LABEL	OPERAT	ADRES1
	[label]	B(cc)	(location)

\DDRESSING MODES SUPPORTED:
program counter relative with displacement
absolute short

(if PC relative with disp. is used the displacement should be decreased by two if the desired displacement is counted from the location of the Bcc instruction.)

CONDITION CODES:

code	condition
HI	high
LS	low or same

CC	carry clear
NE	not equal
CS	carry set
EQ	equal
VC	overflow clear
VS	overflow set
PL	plus
MI	minus
GE	greater or equal
LT	less than
GT	greater than
LE	less or equal
RA	branch always
SR	branch to subroutine

NOTE ON USING Bcc WITH CMP: If Bcc is used after a CMP type instruction, the relation tested is:

DESTINATION condition SOURCE

Where destination and source are from the CMP instruction line.

OPERATION:NEG,NEX - Negate, negate with extend. NEg subtracts the contents of source (ADRES1) operand from zero using two's complement arithmetic. NEX subtracts the source operand and the value of the extend flag from zero. Results are stored in source (ADRES1).

field	LABEL	OPERAT	ADRES1
	[label]	NEG(B)(W)(L)	(source)
	[label]	NEX(B)(L)(W)	(source)
		(specifies data size)	

SOURCE ADDRESSING MODES SUPPORTED:

all except:
address register direct
PC relative with displacement
immediate

OPERATION: ADDQ - Add quick. Adds immediate data of 1-8 to the destination operand and stores result in the destination. Immediate data is in ADRES1 field.

field	LABEL	OPERAT	ADRES1	ADRES2
	[label]	ADDQ(B)(W)(L)	#(data)	(destination)
		(specifies data size)		

ADDRESSING MODES SUPPORTED FOR DESTINATION:

all except:
PC relative with displacement
immediate

CALL STATEMENT IN MAIN PROGRAM:

```
    CALL QADD(LABEL, OPERAT, ADRES1, ADRES2, PCOUNT,
NWORDS, HEXM, BIN1, BIN2)
```

ADDRESS REGISTER DIRECT ADDRESSING OPERATIONS: Perform same operations as MOVE, ADD, and SUB, with the destination (ADRES2) being an address register addressed directly.

field	LABEL	OPERAT	ADRES1	ADRES2
	[label]	MOVEA(W)(L)	(source)	A(n)
	[label]	ADDA(W)(L)	(source)	A(n)
	[label]	SUBA(W)(L)	(source)	A(n)
		(note byte data is not allowed)		

SOURCE ADDRESSING MODES SUPPORTED:

All

WITH SIZE SPEC 'L':

all except immediate

CALL STATEMENT IN MAIN PROGRAM:

```
    CALL OPTA(LABEL, OPERAT, ADRES1, ADRES2, PCOUNT,
NWORDS, HEXM, BIN1, BIN2)
```

IMMEDIATE OPERATIONS: ANDI, ORRI, EORI, SUBI, CMPI, use immediate data as the source operand.

field	LABEL	OPERAT	ADRES1	ADRES2
	[label]	ANDI(B)(W)	#[$](data)	(destination)
	"	ORRI(B)(W)	"	"
	"	EORI(B)(W)	"	"
	"	SUBI(B)(W)	"	"
	"	CMPI(B)(W) (specifies size spec.)	"	"

Perform same functions as AND, ORR, EOR, SUB, CMP. Note that long word data cannot be used.

ADDRESSING MODES SUPPORTED:

```
     source - immediate
     destination - all except:
                   address register direct
                   PC relative with displacement
                   immediate
```

CALL STATEMENT IN MAIN PROGRAM:

```
    CALL IMME(LABEL, OPERAT, ADRES1, ADRES2, PCOUNT,
NWORDS, HEXM, BIN1, BIN2, BIN3)
```

OPERATION: JMP - Unconditional jump to specified memory address.

```
field      LABEL      OPERAT         ADRES1
-------------------------------------------

           [label]    JMP            (address)

           Previous value of program counter is lost.
```

ADDRESSING MODES SUPPORTED:

```
    all except : data register direct
                 address register direct
                 postincrement register indirect
                 predecrement       "        "
                 immediate data
```

OPERATION: JSR - Jump to subroutine and save old value of program counter on system stack.

```
field      LABEL      OPERAT         ADRES1
-------------------------------------------

           [label]    JSR            (address)
```

ADDRESSING MODES SUPPORTED:

same as JMP

CALL STATEMENT IN MAIN PROGRAM (both JMP and JSR):

```
     CALL JUMP(LABEL, OPERAT, ADRES1, ADRES2, PCOUNT,
NWORDS, HEXM, BIN1, BIN2)
```

OPERATION: RTS - Return from subroutine to location stored on stack.

field	LABEL	OPERAT
	[label]	RTS

Will not affect status flags.

OPERATION: MUL - Signed or unsigned multiply. Multiplies two 16-bit operands and yields a 32-bit result which is stored in the data register destination. MULU (unsigned) uses unsigned binary arithmetic, and MULS uses two's complement signed binary arithmetic.

field	LABEL	OPERAT	ADRES1	ADRES2
	[label]	MULS	(source)	D(n)
	[label]	MULU	(source)	D(n)

ADDRESSING MODES SUPPORTED:

source - all except:
address register direct

destination - data register direct

CALL STATEMENT IN MAIN PROGRAM:

```
    CALL MULDIV(LABEL, OPERAT, ADRES1, ADRES2, PCOUNT,
NWORDS, HEXM, BIN1, BIN2)
```

OPERATION: DIV - Signed or unsigned divide. Divides destination (ADRES2) by source (ADRES1), result stored in destination with the quotient in the least significant word and the remainder in the most significant word. DIVU (unsigned) uses binary arithmetic and DIVS uses signed two's complement arithmetic.

field	LABEL	OPERAT	ADRES1	ADRES2
	[label]	DIVS	(source)	D(n)
	[label]	DIVU	(source)	D(n)

ADDRESSING MODES SUPPORTED:

source - all except:
address register direct

destination - data register direct

CALL STATEMENT IN MAIN PROGRAM:
same as MUL

OPERATION: NOP - No operation. Increments program counter.

field	LABEL	OPERAT
	[label]	NOP

CALL STATEMENT IN MAIN PROGRAM:

```
CALL NOP(LABEL, OPERAT, PCOUNT, NWORDS, HEXM, BIN1)
```

OPERATION: STOP - Loads next memory word into status register and stops processor.

field	LABEL	OPERAT
	[label]	STOP

CALL STATEMENT IN MAIN PROGRAM:

same as NOP

OPERATION: SWAP - Swaps data register halves.

field	LABEL	OPERAT	ADRES1
	[label]	SWAP	D(n)

ONLY ADDRESSING IS AS SHOWN

CALL STATEMENT IN MAIN PROGRAM:

```
    CALL SWAP(LABEL, OPERAT, ADRES1, PCOUNT, NWORDS, HEXM)
```

OPERATION: BTST, Test a specified bit in the destination operand and set the zero status flag according to result.

field	LABEL	OPERAT	ADRES1	ADRES2
	[label]	BTST	#(bit no.)	(desination)

DESTINATION ADDRESSING MODES SUPPORTED:

```
                    all except :
                        address register direct
                        immediate data
```

MC68CRX FORTRAN PROGRAM SPECIFICS:

Sections of the MC68CRX Main Program
(See APPENDIX A, program listing)

INITIALIZATION SECTION - Sets up the program and data start locations. START is the input variable which is converted to PCOUNT, the program counter.

FILE NAMING AND OPENING SECTION - User inputs the names of all files to be manipulated in the cross assembly process. The list file is opened and a header is printed in that file.

READ ASSEMBLY LINE SECTION - Opens assembler code file and .M68 file. Reads one line of assembler code into variables LABEL, OPERAT, ADRES1, ADRES2.

CALL SECTION - Matches OPERAT to a string and calls proper subroutine.

PASS CHECK SECTION - Checks variable NSTOP to see if an END has been encountered in the assembly code file. If so, increment NPASS by 1. If NPASS = 3, assembly is complete.

WRITE S-RECORD SECTION - Converts the binary instruction string BIN1 to hex and inserts it into the S-record array. If NWORDS is greater than one, BIN2 and BIN3 (if used) are also converted to hex and inserted into the S-record array. The hex memory location HEXM array is inserted into the S-record array.

COUNT AND CHECKSUM SECTION - Sets up the count and checksum sections of the S-record and inserts them into the S-record array.

SUBROUTINES:

File	Subrotine	Function/Mnemonic
MC68CRX.FTN		Main Program
OPTSUB2.FTN	ANDADD	ADD,AND,ORR,CMP,SUB,EOR
	MOVE	MOVE
	CMP	CMP
	EOR	EOR
	AS	ASL,ASR,LSL,LSR,ROL,ROR
	Bcc	Bcc
	QMOVE	MOVEQ
	QADD	ADDQ
	IMME	ADDI,ANDI,ORRI,EORI
SUBDIR.FTN	EQU	EQU
	DS	DS
	END	END
	OPTA	ADDA,SUBA,MOVEA
	NOP	NOP,STOP
	JUMP	JSR,JMP
	MULDIV	MULU,MULS,DIVU,DIVS
	NEG	NEG,NEX
UTLSUB.FTN	KSTRIN	Separates four character string into a 4 element array, rightmost character becomes the first element.
	TCOMP	Performs a two's complement on the 16 or 32 array sent to the sub-

		routine. (Complements and adds 1 with carry)
	OCOMP	Complements all bits of array sent.
	CKSUM	Computes the checksum for each S record and adds it to the S record array. Also generates list file.
	LABTAB	First pass: sets up table (two parallel arrays) of labels and their locations. Second pass: returns the location of a label name.
	LABAD	Used in conjunction with LABTAB during second pass of assembler.
	TEST	BTST
DCSUB.FTN	DC	DC
SUBS1.FTN	BINDIG	Converts a 16 element character array of binary (1's and 0's) into a 4 byte integer. Element 1 of array is 'ones' place.
	DIGHEX	Integer (4 byte) to four element character array.
SUBS2.FTN	HEXNUM	Hex array to 4 byte integer conversion,
	NUMBIN	4 byte integer to 16 or 32 element character array of binary 1's and 0's.
SUBS3.FTN	ADRLOC	Returns a 3 element character array when sent a single character which is a numeral from

0-7. The 3 element array is a binary representation of the numeral sent.

TADR

Returns the necessary addressing information when sent the contents of an address field.

ADDING MNEMONICS TO THE MC68CRX CROSS ASSEMBLER:

The MC68000 supports over sixty instructions. The most commonly used mnemonics are assembled by the MC68CRX cross assembler. However, if a programming situation occurs which requires an operation not currently in the library of the MC68CRX program, a subroutine (the operation subroutine) can be added to assemble the instruction.

The operation subroutine must contain the following:

NPASS, the variable which counts the number of passes the assembler has made, must be declared as COMMON/BLOCK1/NPASS at the start of the subroutine.

Each operation subroutine must have the variables PCOUNT, NWORDS, and HEXM passed to it. NWORDS must be set to an integer which is the number of memory words the instruction will write (1-3). PCOUNT, the program counter, must be incremented by two for each memory word, preferably just prior to the return staement. After the COMMON statement and type declarations, the following lines must be included.

```
      IF(NPASS.NE.1)GO TO 100
         CALL LABTAB(LABEL,PCOUNT,NA)
         IF(ADRES1(1:1).EQ.'(')ADRES1='$0000'
         IF(ADRES2(1:1).EQ.'(')ADRES2='$0000'
         GO TO 150
100   CALL LABAD(ADRES1,ADRES2)
150   CALL DIGHEX(PCOUNT,HEXM)
```

[These three lines only needed if ADRES1,ADRES2 were sent to the subroutine]

(PCOUNT should be incremented AFTER these lines)

The subroutine should generate and return up to three words of binary code stored in 16 element, single character arrays. The code for the effective address fields of many instructions can be easily obtained by using the subroutine TADR, which is called by:

```
CALL TADR(ADRES, MODE, REG, NUM, TYPE, FLG)
```

ADRES is ADRES1 or ADRES2 (this is the only variable sent TO the subroutine)

MODE and REG are 3 element, single character arrays containing the binary code for the effective address field.

NUM is a 4-byte integer variable which contains an integer equivalent to the value of the 16-bit binary extension word used by some addressing modes. If NUM is to be used, the integer variable FLG will be set to 1 by TADR. NUM can be converted to a binary word array by using:
CALL NUMBIN(NUM, BIN32, BIN2, NZ)
(BIN32 is a 32 element array not used. NZ is a single character variable not used)

TYPE is a single character variable not used.

Each operation/mnemonic subroutine must be called in the CALL SECTION of the main program (MC68CRX).

APPENDIX A
PROGRAM LISTINGS

```
C        MC68CRX
C        MC68ØØØ CROSS ASSEMBLER     KEN ROMANO,IRAP,JUNE 1984
C        COMMENTS REFER TO SECTIONS EXPLAINED IN MC68CRX USERS MANUAL
C
C
         COMMON/BLOCK1/NPASS
         COMMON/BLOKK2/LABEL,OPERAT,ADRES1,ADRES2
         CHARACTER*6 LABEL,OPERAT
         CHARACTER*9 ADRES1,ADRES2,FOUT,FLST
         CHARACTER*1 BIN1(16),BIN2(16),BINL(32)
         CHARACTER*1 BIN3(16),BIN4(16),LOC(3),HEXM(4)
         CHARACTER*1 HEX2(4),HEX3(4),HEX4(4),SREC(3Ø)
         CHARACTER*15 FNAME
         CHARACTER*4 START,NSTOP,DSTART
         INTEGER*4 NUMBER,DCOUNT,PCOUNT,PCONT2,DCONT2
         INTEGER NCK,NWORDS
C
C        INITIALIZATION SECTION
C
         WRITE(5,1ØØ)
  1ØØ    FORMAT(1X,'INPUT MEMORY LOCATION (HEX) AT WHICH TO BEGIN PROGRAM
      &  STORAGE IN MC68ØØØ RAM (<8ØØØ,>Ø6FF)')
         READ(5,111)START
  111    FORMAT(A4)
         WRITE(5,15Ø)
  15Ø    FORMAT(1X,'INPUT MEMORY LOCATION (HEX) AT WHICH TO BEGIN DATA
      &  STORAGE IN MC68ØØØ RAM')
         READ(5,222)DSTART
  222    FORMAT(A4)
         DO 152 J=1,4
            HEXM(-1*J+5)=START(J:J)
            HEX4(-1*J+5)=DSTART(J:J)
  152    CONTINUE
         CALL HEXNUM(HEXM,PCOUNT)
         PCONT2=PCOUNT
         CALL HEXNUM(HEX4,DCOUNT)
         DCONT2=DCOUNT
C
C        FILE NAMING AND OPENING SECTION
C
         WRITE(5,2ØØ)
  2ØØ    FORMAT(1X,'INPUT NAME OF ASSEMBLER CODE FILE')
         READ(5,225)FNAME
  225    FORMAT(A15)
         WRITE(5,3ØØ)
  3ØØ    FORMAT(1X,'INPUT NAME OF OUTPUT (S RECORD) FILE TO BE
      &  CREATED: XXXXX.M68')
         READ(5,23Ø)FOUT
 23Ø     FORMAT(A9)
         WRITE(5,31Ø)
  31Ø    FORMAT(1X,'INPUT NAME OF LIST FILE TO BE CREATED: XXXXX.LST')
         READ(5,24Ø)FLST
  24Ø    FORMAT(A9)
         OPEN(UNIT=11,FILE=FLST,STATUS='NEW')
         WRITE(11,312)
  312    FORMAT(1X,'LABEL',T9,'OPERAT',T17,'ADRES1',T28,'ADRES2',
      $T4Ø,'LOCATION',T5Ø,'HEX DATA')
         WRITE(11,314)
  314    FORMAT(2X)
C
C        INITIALIZE ASSEMBLER
C
         NPASS=1
      CALL LABTAB('XSTART',PCOUNT,1)
C
C     READ ASSEMBLY LINE SECTION
C
 350  OPEN(UNIT=3,FILE=FNAME,READONLY,STATUS='OLD')
      OPEN(UNIT=4,FILE=FOUT,STATUS='NEW')
      REWIND 3
      REWIND 4
      NSTOP='GO'
      PCOUNT=PCONT2
      DCOUNT=DCONT2
      WRITE(4,360)
 360  FORMAT(1X,'S0')
 400  READ(3,440)LABEL,OPERAT,ADRES1,ADRES2
 440  FORMAT(T1,A6,T20,A6,T40,A9,T50,A9)
      NCK=0
      DO 441 KK=1,30
         SREC(KK)=' '
 441  CONTINUE
C
C     CALL SECTION
C     IDENTIFY MNEMONIC AND CALL PROPER SUBROUTNES
C
      IF(OPERAT(1:4).NE.'SUBA')GO TO 371
 370  CALL OPTA(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,NWORDS,
     $HEXM,BIN1,BIN2)
         GO TO 498
 371  IF(OPERAT(1:4).NE.'ADDA')GO TO 372
         GO TO 370
 372  IF(OPERAT(1:5).NE.'MOVEA')GO TO 373
         GO TO 370
 373  IF(OPERAT(1:5).NE.'MOVEQ')GO TO 374
      CALL QMOVE(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,NWORDS,
     $HEXM,BIN1)
         GO TO 498
 374  IF(OPERAT(1:4).NE.'ADDQ')GO TO 375
      CALL QADD(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,NWORDS,
     $HEXM,BIN1,BIN2)
         GO TO 498
 375  IF(OPERAT(1:3).NE.'NOP')GO TO 377
 376  CALL NOP(LABEL,OPERAT,PCOUNT,NWORDS,HEXM,BIN1)
         GO TO 498
 377  IF(OPERAT(1:4).NE.'STOP')GO TO 378
         GO TO 376
 378  IF(OPERAT(1:3).EQ.'JSR')GO TO 380
      IF(OPERAT(1:3).EQ.'RTS')GO TO 380
      IF(OPERAT(1:3).NE.'JMP')GO TO 381
 380  CALL JUMP(LABEL,OPERAT,ADRES1,PCOUNT,NWORDS,
     $HEXM,BIN1,BIN2)
         GO TO 498
 381  IF(OPERAT(1:3).EQ.'MUL')GO TO 382
      IF(OPERAT(1:3).NE.'DIV')GO TO 383
 382  CALL MULDIV(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,
     $NWORDS,HEXM,BIN1,BIN2)
         GO TO 498
 383  IF(OPERAT(1:3).EQ.'NEG')GO TO 384
      IF(OPERAT(1:3).NE.'NEX')GO TO 385
 384  CALL NEG(LABEL,OPERAT,ADRES1,PCOUNT,NWORDS,HEXM,
     $BIN1,BIN2)
         GO TO 498
 385  IF(OPERAT(1:4).NE.'SWAP')GO TO 386
      CALL SWAP(LABEL,OPERAT,ADRES1,PCOUNT,NWORDS,HEXM,
     $BIN1)
         GO TO 498
 386  IF(OPERAT(1:4).NE.'EORI')GO TO 387
         GO TO 409
```

```
387     IF (OPERAT(1:4) .NE. 'BTST') GO TO 399
          CALL TEST(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,NWORDS,
     $HEXM,BIN1,BIN2,BIN3)
          GO TO 498
399     IF(OPERAT(1:4).NE.'ADDI')GO TO 401
409     CALL IMME(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,NWORDS,
     $HEXM,BIN1,BIN2,BIN3)
          GO TO 498
401     IF(OPERAT(1:4).NE.'ANDI')GO TO 402
          GO TO 409
402     IF(OPERAT(1:4).NE.'ORRI')GO TO 403
          GO TO 409
403     IF(OPERAT(1:3).NE.'EOR')GO TO 404
        CALL EOR(OPERAT)
        CALL ANDADD(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,NWORDS,
     $HEXM,BIN1,BIN2)
          GO TO 498
404     IF(OPERAT(1:4).NE.'SUBI')GO TO 405
          GO TO 409
405     IF(OPERAT(1:4).NE.'CMPI')GO TO 410
          GO TO 409
410     IF(OPERAT(:2).NE.'DC')GO TO 411
          CALL DC(LABEL,OPERAT,ADRES1,DCOUNT,NCK)
          GO TO 498
411     IF(OPERAT.NE.'END')GO TO 412
          CALL END(PCONT2,NSTOP)
          GO TO 498
412     IF(OPERAT(:2).NE.'DS')GO TO 413
          CALL DS(LABEL,OPERAT,DCOUNT,NCK)
          GO TO 498
413     IF(OPERAT.NE.'EQU')GO TO 414
          CALL EQU(LABEL,ADRES1,NCK)
          GO TO 498
414     IF(OPERAT(1:3).NE.'AND')GO TO 415
         CALL ANDADD(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,NWORDS,HEXM,BIN1,
     $BIN2)
          GO TO 498
415     IF(OPERAT(1:3).NE.'ADD')GO TO 416
         CALL ANDADD(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,NWORDS,HEXM,BIN1,
     $BIN2)
          GO TO 498
416     IF(OPERAT(1:3).NE.'ORR')GO TO 417
         CALL ANDADD(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,NWORDS,HEXM,BIN1,
     $BIN2)
          GO TO 498
417     IF(OPERAT(1:3).NE.'CMP')GO TO 418
         CALL CMP(OPERAT)
         CALL ANDADD(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,NWORDS,HEXM,BIN1,
     $BIN2)
          GO TO 498
418     IF(OPERAT(1:4).NE.'MOVE')GO TO 419
        CALL MOVE(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,NWORDS,HEXM,BIN1,
     $BIN2,BIN3)
          GO TO 498
419     IF(OPERAT(1:2).NE.'AS')GO TO 420
         CALL AS(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,NWORDS,HEXM,
     $BIN1,BIN2)
          GO TO 498
420     IF(OPERAT(1:2).NE.'LS')GO TO 442
         CALL AS(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,NWORDS,HEXM,
     $BIN1,BIN2)
          GO TO 498
442     IF(OPERAT(1:3).NE.'SUB')GO TO 452
         CALL ANDADD(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,NWORDS,
     $HEXM,BIN1,BIN2)
          GO TO 498
```

```
 492      IF (OPERAT(1:1).NE.'B')GO TO 496
          CALL BCC(LABEL,OPERAT,ADRES1,PCOUNT,NWORDS,HEXM,BIN1,BIN2)
             GO TO 498
 496      WRITE(5,500)OPERAT
 500      FORMAT(1X,'INVALID COMMAND : ',A6,' -EXECUTION TERMINATED')
          STOP
C
C         PASS CHECK SECTION
C
 498      IF(NSTOP.NE.'STOP')GO TO 510
          NPASS=NPASS+1
          IF(NPASS.EQ.3)STOP
          CLOSE (UNIT=3,STATUS='KEEP')
          CLOSE (UNIT=4,STATUS='DELETE')
          GO TO 350
C
C         WRITE/NO WRITE CHECK
C
 510      IF(NCK.EQ.1)GO TO 400
C
C         WRITE S-RECORD SECTION
C
          SREC(1)='S'
          SREC(2)='1'
          CALL BINDIG(BIN1,NUMBER)
          CALL DIGHEX(NUMBER,HEX2)
          DO 1000 J=1,4
             SREC(J+8)=HEX2(-1*J+5)
1000      CONTINUE
          IF(NWORDS.EQ.1)GO TO 1010
             CALL BINDIG(BIN2,NUMBER)
             CALL DIGHEX(NUMBER,HEX3)
             DO 1001 J=1,4
                  SREC(J+12)=HEX3(-1*J+5)
1001         CONTINUE
             IF(NWORDS.EQ.2)GO TO 1010
                  CALL BINDIG(BIN3,NUMBER)
                  CALL DIGHEX(NUMBER,HEX4)
                  DO 1002 J=1,4
                     SREC(J+16)=HEX4(-1*J+5)
1002              CONTINUE
1010      DO 1003 J=1,4
            SREC(J+4)=HEXM(-1*J+5)
1003      CONTINUE
C
C         COUNT AND CHEKSUM SECTION
C
          IF(NWORDS.NE.3)GO TO 1020
             SREC(3)='0'
             SREC(4)='9'
             CALL CKSUM(SREC,3)
             GO TO 1050
1020      IF(NWORDS.NE.2)GO TO 1030
             SREC(3)='0'
             SREC(4)='7'
             CALL CKSUM(SREC,2)
             GO TO 1050
1030      SREC(3)='0'
          SREC(4)='5'
          CALL CKSUM(SREC,1)
C
C         WRITE S RECORDS TO .M68 FILE
1050      WRITE(4,5900)(SREC(J),J=1,30)
5900      FORMAT(1X,30A1)
          GO TO 400
C
```

```
C       CLOSE FILES
C
9999    CONTINUE
        CLOSE(UNIT=3,STATUS='KEEP')
        CLOSE(UNIT=4,STATUS='KEEP')
        CLOSE(UNIT=11,STATUS='KEEP')
        STOP
        END
```

SUBS1.FTN

```
C
C     BINARY TO DECIMAL CONVERSION
      SUBROUTINE BINDIG(BINARY,NUMBER)
      CHARACTER*1 BINARY(16)
      INTEGER*4 NUMBER,K
      INTEGER*4 MULT
      NUMBER=Ø
      DO 5Ø K=1,16
        IF(BINARY(K),NE.'1')GO TO 5Ø
             MULT=2**(K-1)
             NUMBER=NUMBER+MULT
 5Ø   CONTINUE
      RETURN
      END
C
C
C     DECIMAL TO HEX CONVERSION SUBROUTINE
      SUBROUTINE DIGHEX(NUMBER,HEX)
      INTEGER*4 NUMBER
      CHARACTER*1 HEX(4)
      ANUM=FLOATJ(NUMBER)
      DO 1ØØ K=4,1,-1
        DIVID=ANUM/(16,**(K-1))
        NREM=IINT(DIVID)
        IF(NREM,GT,15)GO TO 999
        IF(NREM,NE,15)GO TO 5
             HEX(K)='F'
             GO TO 99
  5     IF(NREM,NE,14)GO TO 1Ø
             HEX(K)='E'
             GO TO 99
 1Ø     IF(NREM,NE,13)GO TO 15
             HEX(K)='D'
             GO TO 99
 15     IF(NREM,NE,12)GO TO 2Ø
             HEX(K)='C'
             GO TO 99
 2Ø     IF(NREM,NE,11)GO TO 25
             HEX(K)='B'
             GO TO 99
 25     IF(NREM,NE,1Ø)GO TO 3Ø
             HEX(K)='A'
             GO TO 99
 3Ø     IF(NREM,NE,9)GO TO 35
             HEX(K)='9'
             GO TO 99
 35     IF(NREM,NE,8)GO TO 4Ø
             HEX(K)='8'
             GO TO 99
 4Ø     IF(NREM,NE,7)GO TO 45
             HEX(K)='7'
             CO TO 99
 45     IF(NREM,NE,6)GO TO 5Ø
             HEX(K)='6'
             GO TO 99
 5Ø     IF(NREM,NE,5)GO TO 55
             HEX(K)='5'
             GO TO 99
 55     IF(NREM,NE,4)GO TO 6Ø
             HEX(K)='4'
             GO TO 99
 6Ø     IF(NREM,NE,3)GO TO 65
             HEX(K)='3'
```

```
                    GO TO 99
65          IF(NREM.NE.2)GO TO 70
                 HEX(K)='2'
                 GO TO 99
70          IF(NREM.NE.1)GO TO 75
                 HEX(K)='1'
                 GO TO 99
75          IF(NREM.NE.0)GO TO 80
                 HEX(K)='0'
                 GO TO 99
80          WRITE(5,111)
111         FORMAT(1X,'NOT HEX ERROR - FATAL')
            STOP
99          REM=FLOATI(NREM)
            ANUM=ANUM-REM*(16.**(K-1))
100      CONTINUE
         RETURN
999      WRITE(5,222)
222      FORMAT(1X,'OUT OF BOUNDS IN HEX SUB. - FATAL')
         STOP
         END
```

SUBS2.FTN

```
C
C        HEX TO DECIMAL CONVERSION SUBROUTINE
         SUBROUTINE HEXNUM(HEX,NUMBER)
         CHARACTER*1 HEX(4)
         INTEGER*4 NUMBER,MULT,NDIG,K
         NUMBER=0
         DO 200 K=1,4
            IF(HEX(K).NE.'F')GO TO 5
                 NDIG=15
                 GO TO 111
 5          IF(HEX(K).NE.'E')GO TO 10
                 NDIG=14
                 GO TO 111
 10         IF(HEX(K).NE.'D')GO TO 15
                 NDIG=13
                 GO TO 111
 15         IF(HEX(K).NE.'C')GO TO 20
                 NDIG=12
                 GO TO 111
 20         IF(HEX(K).NE.'B')GO TO 25
                 NDIG=11
                 GO TO 111
 25         IF(HEX(K).NE.'A')GO TO 30
                 NDIG=10
                 GO TO 111
 30         IF(HEX(K).NE.'9')GO TO 35
                 NDIG=9
                 GO TO 111
 35         IF(HEX(K).NE.'8')GO TO 40
                 NDIG=8
                 GO TO 111
 40         IF(HEX(K).NE.'7')GO TO 45
                 NDIG=7
                 GO TO 111
 45         IF(HEX(K).NE.'6')GO TO 50
                 NDIG=6
                 GO TO 111
 50         IF(HEX(K).NE.'5')GO TO 55
                 NDIG=5
                 GO TO 111
 55         IF(HEX(K).NE.'4')GO TO 60
                 NDIG=4
                 GO TO 111
 60         IF(HEX(K).NE.'3')GO TO 65
                 NDIG=3
                 GO TO 111
 65         IF(HEX(K).NE.'2')GO TO 70
                 NDIG=2
                 GO TO 111
 70         IF(HEX(K).NE.'1')GO TO 75
                 NDIG=1
                 GO TO 111
 75         IF(HEX(K).NE.'0')GO TO 80
                 NDIG=0
                 GO TO 111
 80         WRITE(5,100)
 100        FORMAT(1X,'NOT HEX ERROR - FATAL')
            STOP
 111        MULT=(16**(K-1))*NDIG
            NUMBER=NUMBER+MULT
 200     CONTINUE
         RETURN
         END
```

```
C
C        DECIMAL TO BINARY SUBROUTINE
         SUBROUTINE NUMBIN(NUMBER,BIN32,BIN16,NFLAG)
         CHARACTER*1 BIN32(32),BIN16(16)
         INTEGER*4 NUMBER,N,NUM2
         NFLAG=0
         NUM2=NUMBER
         DO 60 K=1,32
            BIN32(K)='0'
 60      CONTINUE
         DO 70 K=1,16
            BIN16(K)='0'
 70      CONTINUE
         DO 100 N=31,1,-1
            IF(NUMBER.LT.(2**(N-1)))GO TO 100
                 BIN32(N)='1'
                 NUMBER=NUMBER-(2**(N-1))
 100     CONTINUE
         DO 200 N=16,1,-1
            IF(NUM2.LT.(2**(N-1)))GO TO 200
                 BIN16(N)='1'
                 NUM2=NUM2-(2**(N-1))
 200     CONTINUE
         IF(NUM2.GT.0)NFLAG=1
         RETURN
         END
```

SUBS3.FTN

```
C
C       ADRESS LOCATION SUBROUTINE
        SUBROUTINE ADRLOC(NUM,LOC)
        CHARACTER*1 NUM,LOC(3)
        DO 33 K=1,3
           LOC(K)='0'
 33     CONTINUE
        IF(NUM.NE.'0')GO TO 5
           GO TO 250
 5      IF(NUM.NE.'1')GO TO 10
           LOC(1)='1'
           GO TO 250
 10     IF(NUM.NE.'2')GO TO 15
           LOC(2)='1'
           GO TO 250
 15     IF(NUM.NE.'4')GO TO 20
           LOC(3)='1'
           GO TO 250
 20     IF(NUM.NE.'3')GO TO 50
           LOC(1)='1'
           LOC(2)='1'
           GO TO 250
 50     IF(NUM.NE.'5')GO TO 100
           LOC(1)='1'
           LOC(3)='1'
           GO TO 250
 100    IF(NUM.NE.'6')GO TO 150
           LOC(2)='1'
           LOC(3)='1'
           GO TO 250
 150    IF(NUM.NE.'7')GO TO 200
           LOC(1)='1'
           LOC(2)='1'
           LOC(3)='1'
           GO TO 250
 200    WRITE(5,333)NUM
 333    FORMAT(1X,A1,'  IS NOT A VALID REGISTER NUMBER - EXECUTION
     $  TERMINATED')
        STOP
 250    RETURN
        END
C
C       ADRESS MODE AND LOCATION SUBROUTINE
        SUBROUTINE TADR(ADRES,MODE,REG,NUM,TYPE,FLG)
        CHARACTER*9 ADRES,SWITCH,ADRES1
        CHARACTER*1 MODE(3),REG(3),TYPE,R,HEX(4)
        CHARACTER*1 BIN16(16),BIN32(32)
        INTEGER FLG,NO
        INTEGER*4 NUM,NUMBER
        IF(ADRES(:1).EQ.'D')GO TO 100
        IF(ADRES(:1).EQ.'A')GO TO 200
        IF(ADRES(:1).EQ.'@')GO TO 300
        IF(ADRES(:1).EQ.'+')GO TO 400
        IF(ADRES(:1).EQ.'-')GO TO 450
        IF(ADRES(:1).EQ.'%')GO TO 500
        IF(ADRES(:1).EQ.'P')GO TO 700
        IF(ADRES(:1).EQ.'$')GO TO 600
        IF(ADRES(:1).EQ.'#')GO TO 800
        WRITE(5,77)ADRES(1:1)
 77     FORMAT(1X,'IMPROPER ADRESSING SPECIFIER :  ',A1,' FATAL')
        STOP
C
C       DATA REGISTER DIRECT
```

```
  100     TYPE='0'
          MODE(1)='0'
          MODE(2)='0'
          MODE(3)='0'
          GO TO 250
C
C         ADRESS REGISTER DIRECT
  200     TYPE='1'
          MODE(1)='1'
          MODE(2)='0'
          MODE(3)='0'
  250     R=ADRES(2:2)
          CALL ADRLOC(R,REG)
          FLG=0
          GO TO 900
C
C         ADRESS REGISTER INDIRECT
  300     TYPE='1'
          R=ADRES(3:3)
          CALL ADRLOC(R,REG)
          MODE(1)='0'
          MODE(2)='1'
          MODE(3)='0'
          FLG=0
          GO TO 900
C
C         ADRESS REGISTER IND, WITH POST INCREMENT
  400     TYPE='1'
          R=ADRES(3:3)
          CALL ADRLOC(R,REG)
          MODE(1)='1'
          MODE(2)='1'
          MODE(3)='0'
          FLG=0
          GO TO 900
C
C         ADRESS REGISTER IND, WITH PRE-DECREMENT
  450     TYPE='1'
          R=ADRES(3:3)
          CALL ADRLOC(R,REG)
          MODE(1)='0'
          MODE(2)='0'
          MODE(3)='1'
          FLG=0
          GO TO 900
C
C         ADRESS REGISTER INDIRECT WITH DISPLACEMENT
  500     TYPE='1'
          NO=0
          IF(ADRES(2:2).EQ.'$')GO TO 520
          IF(ADRES(2:2).NE.'-')GO TO 505
             ADRES1=ADRES(3:7)
             NO=1
             GO TO 510
  505     ADRES1=ADRES(2:6)
  510     OPEN(UNIT=2,FILE='TEMP.DAT',STATUS='NEW')
          WRITE(2,515)ADRES1
  515     FORMAT(1X,A9)
          REWIND 2
          READ(2,517)NUM
  517     FORMAT(I9)
          CLOSE(UNIT=2,STATUS='DELETE')
          GO TO 540
  520     M=4
          DO 525 J=3,6
             HEX(M)=ADRES(J:J)
          M=M-1
  525     CONTINUE
          CALL HEXNUM(HEX,NUM)
  540     IF(ADRES(2:2).NE.'-')GO TO 570
              CALL NUMBIN(NUM,BIN32,BIN16,NF)
              CALL TCOMP(BIN16,BIN32,NF)
              CALL BINDIG(BIN16,NUM)
  570     FLG=1
          KL=8+NO
          R=ADRES(KL:KL)
          CALL ADRLOC(R,REG)
          MODE(1)='1'
          MODE(2)='0'
          MODE(3)='1'
          GO TO 900
C
C         ABSOLUTE SHORT
 600      TYPE='1'
          FLG=1
          MODE(1)='1'
          MODE(2)='1'
          MODE(3)='1'
          CALL ADRLOC('0',REG)
          CALL KSTRIN(ADRES(2:5),HEX)
          CALL HEXNUM(HEX,NUM)
          GO TO 900
C
C         PC AND DISPLACEMENT
  700     TYPE='1'
          FLG=1
          MODE(1)='1'
          MODE(2)='1'
          MODE(3)='1'
          CALL ADRLOC('2',REG)
          NO=0
          IF(ADRES(3:3).EQ.'S')GO TO 720
          IF(ADRES(3:3).NE.'-')GO TO 705
              ADRES1=ADRES(4:8)
              NO=1
              GO TO 710
  705     ADRES1=ADRES(3:7)
  710     OPEN(UNIT=2,FILE='TEMP.DAT',STATUS='NEW')
          WRITE(2,715)ADRES1
  715     FORMAT(1X,A9)
          REWIND 2
          READ(2,717)NUM
  717     FORMAT(I9)
          CLOSE(UNIT=2,STATUS='DELETE')
          GO TO 740
  720     M=4
          DO 725 J=4,7
              HEX(M)=ADRES(J:J)
              M=M-1
  725     CONTINUE
  740     IF(ADRES(3:3).NE.'-')GO TO 770
              CALL NUMBIN(NUM,BIN32,BIN16,NF)
              CALL TCOMP(BIN16,BIN32,NF)
              CALL BINDIG(BIN16,NUM)
  770     GO TO 900
C
C         IMMEDIATE
  800     TYPE='1'
          FLG=1
          MODE(1)='1'
          MODE(2)='1'
          MODE(3)='1'
```

```
      CALL ADRLOC('4',REG)
      IF(ADRES(2:2).NE.'$')GO TO 850
         CALL KSTRIN(ADRES(3:6),HEX)
         CALL HEXNUM(HEX,NUM)
      GO TO 900
850   IF(ADRES(2:2).NE.'-')GO TO 855
         ADRES1=ADRES(3:7)
         GO TO 860
855   ADRES1=ADRES(2:6)
860   OPEN(UNIT=2,FILE='TEMP.DAT',STATUS='NEW')
      WRITE(2,862)ADRES1
862   FORMAT(1X,A9)
      REWIND 2
      READ(2,844)NUM
844   FORMAT(I9)
      CLOSE(UNIT=2,STATUS='DELETE')
      IF(ADRES(2:2).NE.'-')GO TO 900
         CALL NUMBIN(NUM,BIN32,BIN16,NF)
         CALL TCOMP(BIN16,BIN32,NF)
         CALL BINDIG(BIN16,NUM)
900   RETURN
      END
```

DCSUB.FTN

```
C       DIRECTIVES :  DCB,DCL,DCW
        SUBROUTINE DC(LABEL,OPERAT,ADRES1,DCOUNT,NCK)
        CHARACTER*6 LABEL,OPERAT
        CHARACTER*9 ADRES1,SWITCH
        INTEGER Z,NCK,K,NF,NASC,J
        INTEGER*4 DCOUNT,CONST,DSAVE,HOLD
        INTEGER*4 INTEX,INTEY,INTEZ
        BYTE IVAR
        CHARACTER*1 SREC(30),ASCII,HEXM(4),HEX(4),HEX2(4)
        CHARACTER*1 BIN16(16),BIN32(32),BINT(16),VAR
        EQUIVALENCE (IVAR,VAR)
        IF(OPERAT(3:3).EQ.'B')GO TO 50
           ACOUNT=FLOATJ(DCOUNT)
           AXX=(ACOUNT/2.)*10.
           INTEX=JINT(ACOUNT/2.)
           INTEZ=10*INTEX
           INTEY=JINT(AXX)
        IF(INTEZ.NE.INTEY)DCOUNT=DCOUNT+1
 50     Z=0
        IVAR=39
        IF(ADRES1(:1).NE.VAR)GO TO 100
           ASCII=ADRES1(2:2)
           NASC=ICHAR(ASCII)
           REAL=FLOATI(NASC)
           CONST=JIFIX(REAL)
           GO TO 300
 100    IF(ADRES1(:1).NE.'-')GO TO 200
           SWITCH=ADRES1
           ADRES1=SWITCH(2:)
           Z=1
 200    OPEN(UNIT=2,FILE='TEMP.DAT',STATUS='NEW')
        REWIND 2
        WRITE(2,150)ADRES1
 150    FORMAT(1X,A9)
        REWIND 2
        READ(2,111)CONST
 111    FORMAT(I9)
        CLOSE(UNIT=2,STATUS='DELETE')
 300    DSAVE=DCOUNT
        CALL LABTAB(LABEL,DSAVE,K)
        SREC(1)='S'
        SREC(2)='1'
        IF(OPERAT(3:3).NE.'B')GO TO 400
        CALL DIGHEX(CONST,HEX)
        SREC(3)='0'
        SREC(4)='4'
        SREC(9)=HEX(2)
        SREC(10)=HEX(1)
        CALL DIGHEX(DCOUNT,HEXM)
        DO 310 J=1,4
           SREC(J+4)=HEXM(-1*J+5)
 310    CONTINUE
        CALL CKSUM(SREC,0)
        DCOUNT=DCOUNT+1
        GO TO 999
 400    IF(OPERAT(3:3).NE.'W')GO TO 500
           CALL DIGHEX(DCOUNT,HEXM)
           SREC(3)='0'
           SREC(4)='5'
           IF(Z.NE.1)GO TO 405
              CALL NUMBIN(CONST,BIN32,BIN16,NF)
              CALL TCOMP(BIN16,BIN32,NF)
              CALL BINDIG(BIN16,CONST)
```

```
405        CALL DIGHEX (CONST, HEX)
           DO 410 J=1,4
              SREC(J+4)=HEXM(-1*J+5)
              SREC(J+8)=HEX(-1*J+5)
 410       CONTINUE
           CALL CKSUM(SREC,1)
           DCOUNT=DCOUNT+2
           GO TO 999
 500    CALL NUMBIN(CONST,BIN32,BIN16,NF)
        IF(Z.NE.1)GO TO 505
           NF=1
           CALL TCOMP(BIN16,BIN32,NF)
 505    DO 510 J=17,32
           BINT(J-16)=BIN32(J)
 510    CONTINUE
        CALL BINDIG(BINT,HOLD)
        CALL DIGHEX(HOLD,HEX)
        DO 520 J=1,16
           BIN16(J)=BIN32(J)
 520    CONTINUE
        CALL BINDIG(BIN16,HOLD)
        CALL DIGHEX(HOLD,HEX2)
        SREC(3)='0'
        SREC(4)='7'
        CALL DIGHEX(DCOUNT,HEXM)
        DO 530 J=1,4
           SREC(J+4)=HEXM(-1*J+5)
           SREC(J+8)=HEX(-1*J+5)
           SREC(J+12)=HEX2(-1*J+5)
 530    CONTINUE
        CALL CKSUM(SREC,2)
        DCOUNT=DCOUNT+4
C
 999    NCK=1
        WRITE(4,1000)(SREC(J),J=1,30)
1000    FORMAT(1X,30A1)
        RETURN
        END
```

SUBDIR.FTN

```
C       DIRECTIVE :  EQU
        SUBROUTINE EQU(LABEL,ADRES,NCK)
        CHARACTER*6 LABEL
        CHARACTER*9 ADRES
        CHARACTER*1 REG(3),MODE(3)
        INTEGER*4 NUM
        IF(NPASS.EQ.2)GO TO 100
           CALL TADR(ADRES,MODE,REG,NUM)
           CALL LABTAB(LABEL,NUM,NB)
 100    NCK=1
        RETURN
        END
C
C       DIRECTIVE :  DS
        SUBROUTINE DS(LABEL,OPERAT,DCOUNT,NCK)
        CHARACTER*6 LABEL,OPERAT
        INTEGER NCK,K
        INTEGER*4 DCOUNT,INTEZ,INTEY,DSAVE
        IF(OPERAT(3:3).EQ.'B')GO TO 100
           ACOUNT=FLOATJ(DCOUNT)
           AXX=(ACOUNT/2.)*10.
           INTEZ=10*JINT(ACOUNT/2.)
           INTEY=JINT(AXX)
        IF(INTEZ.NE.INTEY)DCOUNT=DCOUNT+1
 100    DSAVE=DCOUNT
        CALL LABTAB(LABEL,DSAVE,K)
        IF(OPERAT(3:3).NE.'B')GO TO 200
           DCOUNT=DCOUNT+1
           GO TO 500
 200    IF(OPERAT(3:3).NE.'L')GO TO 300
           DCOUNT=DCOUNT+4
           GO TO 500
 300    DCOUNT=DCOUNT+2
 500    NCK=1
        RETURN
        END
C
C       DIRECTIVE :  END
        SUBROUTINE END(PCONT2,NSTOP)
        INTEGER*4 PCONT2
        CHARACTER*4 NSTOP
        CHARACTER*1 SREC(30),HEX(4)
        SREC(1)='S'
        SREC(2)='9'
        DO 50 J=1,6
        SREC(J+2)='0'
 50     CONTINUE
        WRITE(4,100)(SREC(J),J=1,8)
 100    FORMAT(1X,8A1)
        NSTOP='STOP'
        RETURN
        END
C
C
C       ADDRESS DIRECT DEST, ADD,SUB
        SUBROUTINE OPTA(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,
     $NWORDS,HEXM,BIN1,BIN2)
        COMMON/BLOCK1/NPASS
        CHARACTER*6 LABEL,OPERAT
        CHARACTER*9 ADRES1,ADRES2
        CHARACTER*1 BIN1(16),BIN2(16),BIN32(32),HEXM(4)
        CHARACTER*1 REG(3),DREG(3),MODE(3),TYPE
        INTEGER FLG,NWORDS
        INTEGER*4 PCOUNT,NUM
```

```
      INTEGER*4 PCOUNT,NUM
C
      IF(NPASS.NE.1)GO TO 20
         CALL LABTAB(LABEL,PCOUNT,NK)
         IF(ADRES1(1:1).EQ.'(')ADRES1='$0000'
         GO TO 30
 20   CALL LABAD(ADRES1,ADRES2)
 30   CALL DIGHEX(PCOUNT,HEXM)
C
      IF(ADRES2(1:1).NE.'A')GO TO 50
C
      IF(OPERAT(1:5).NE.'MOVEA')GO TO 34
         DO 32 J=1,16
            BIN1(J)='0'
 32         CONTINUE
         BIN1(14)='1'
         BIN1(7)='1'
         IF(OPERAT(6:6).NE.'W')GO TO 33
            BIN1(13)='1'
            GO TO 58
 33      IF(OPERAT(6:6).NE.'L')GO TO 50
            GO TO 58
 34   DO 35 J=1,16
         BIN1(J)='1'
 35   CONTINUE
      IF(OPERAT(5:5).NE.'W')GO TO 40
         BIN1(9)='0'
         GO TO 55
 40   IF(OPERAT(5:5).NE.'L')GO TO 50
         GO TO 55
 50   WRITE(5,52)OPERAT
 52   FORMAT(1X,'IMPROPER SIZE SPEC OR ADDRESS MODE FOR :',A6)
      STOP
 55   BIN1(14)='0'
      IF(OPERAT(1:3).EQ.'SUB')BIN1(15)='0'
C
 58   CALL TADR(ADRES2,MODE,DREG,NUM,TYPE,FLG)
      CALL TADR(ADRES1,MODE,REG,NUM,TYPE,FLG)
      DO 60 J=1,3
         BIN1(J+9)=DREG(J)
         BIN1(J)=REG(J)
         BIN1(J+3)=MODE(J)
 60   CONTINUE
      NWORDS=1
      PCOUNT=PCOUNT+2
      IF(FLG.EQ.0)GO TO 100
         NWORDS=2
         PCOUNT=PCOUNT+2
         CALL NUMBIN(NUM,BIN32,BIN2,NZ)
 100  RETURN
      END

C
C     NO OPERATION,STOP
      SUBROUTINE NOP(LABEL,OPERAT,PCOUNT,NWORDS,HEXM,BIN1)
      COMMON/BLOCK1/NPASS
      CHARACTER*6 LABEL,OPERAT
      INTEGER*4 PCOUNT
      CHARACTER*1 BIN1(16),HEXM(4)
      IF(NPASS.NE.1)GO TO 20
         CALL LABTAB(LABEL,PCOUNT,K)
 20   CALL DIGHEX(PCOUNT,HEXM)
      NWORDS=1
      PCOUNT=PCOUNT+2
      DO 30 J=1,16
         BIN1(J)='0'
 30   CONTINUE
 30     CONTINUE
        BIN1(15)='1'
        BIN1(12)='1'
        BIN1(11)='1'
        BIN1(10)='1'
        BIN1(7)='1'
        BIN1(6)='1'
        BIN1(5)='1'
        BIN1(1)='1'
        IF(OPERAT(1:4).NE.'STOP')GO TO 40
           BIN1(2)='1'
           BIN1(1)='0'
 40     CONTINUE
        RETURN
        END
C
C
C       JUMP,JUMP TO SUBROUTINE (JMP,JSR)
        SUBROUTINE JUMP(LABEL,OPERAT,ADRES1,PCOUNT,NWORDS,
     $HEXM,BIN1,BIN2)
        COMMON/BLOCK1/NPASS
        CHARACTER*1 BIN1(16),BIN2(16),BIN32(32),HEXM(4)
        CHARACTER*1 MODE(3),REG(3),TYPE
        CHARACTER*6 LABEL,OPERAT
        CHARACTER*9 ADRES1,ADRESD
        INTEGER*4 PCOUNT,NUM
        INTEGER FLG
        ADRESD='$0000'
        IF(NPASS.NE.1)GO TO 20
           CALL LABTAB(LABEL,PCOUNT,NA)
           IF(ADRES1(1:1).EQ.'(')ADRES1='$0000'
           GO TO 30
 20     CALL LABAD(ADRES1,ADRESD)
 30     CALL DIGHEX(PCOUNT,HEXM)
        DO 40 J=1,16
           BIN1(J)='1'
 40     CONTINUE
        BIN1(16)='0'
        BIN1(14)='0'
        BIN1(13)='0'
        BIN1(9)='0'
        IF (OPERAT(1:3).NE.'RTS')GO TO 45
           FLG=0
           BIN1(2)='0'
           BIN1(4)='0'
           BIN1(8)='0'
           GO TO 50
 45     CALL TADR(ADRES1,MODE,REG,NUM,TYPE,FLG)
        DO 50 J=1,3
           BIN1(J)=REG(J)
           BIN1(J+3)=MODE(J)
 50     CONTINUE
        NWORDS=1
        PCOUNT=PCOUNT+2
        IF(FLG.NE.1)GO TO 70
           NWORDS=2
           PCOUNT=PCOUNT+2
           CALL NUMBIN(NUM,BIN32,BIN2,NZ)
 70     IF(OPERAT(2:3).EQ.'SR')BIN1(7)='0'
        RETURN
        END
C
C
C       SUBROUTINE MULDIV,MULTIPLY,DIVIDE
        SUBROUTINE MULDIV(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,
     $NWORDS,HEXM,BIN1,BIN2)
```

```
      COMMON/BLOCK1/NPASS
      CHARACTER*6 LABEL,OPERAT
      CHARACTER*9 ADRES1,ADRES2
      CHARACTER*1 DREG(3),HEXM(4),BIN32(32),MODE(3),REG(3)
      CHARACTER*1 TYPE,BIN1(16),BIN2(16)
      INTEGER*4 NUM,PCOUNT
      INTEGER FLG
C
      IF(NPASS.NE.1)GO TO 20
         CALL LABTAB(LABEL,PCOUNT,NA)
         IF(ADRES1(1:1).EQ.'(')ADRES1='$0000'
         GO TO 30
 20   CALL LABAD(ADRES1,ADRES2)
 30   CALL DIGHEX(PCOUNT,HEXM)
      DO 40 J=1,16
         BIN1(J)='1'
 40   CONTINUE
      BIN1(13)='0'
      BIN1(14)='0'
      IF(OPERAT(1:3).EQ.'DIV')BIN1(15)='0'
      IF(OPERAT(4:4).EQ.'S')GO TO 50
         BIN1(9)='0'
 50   IF(ADRES2(1:1).EQ.'D')GO TO 60
         WRITE(5,555)OPERAT
 555     FORMAT(1X,'IMPROPER ADDRESSING FOR :',A6)
         STOP
 60   CALL TADR(ADRES2,MODE,DREG,NUM,TYPE,FLG)
      CALL TADR(ADRES1,MODE,REG,NUM,TYPE,FLG)
      DO 70 J=1,3
         BIN1(J)=REG(J)
         BIN1(J+3)=MODE(J)
         BIN1(J+9)=DREG(J)
 70   CONTINUE
      NWORDS=1
      PCOUNT=PCOUNT+2
      IF(FLG.NE.1)GO TO 80
         NWORDS=2
         PCOUNT=PCOUNT+2
         CALL NUMBIN(NUM,BIN32,BIN2,NZ)
 80   RETURN
      END
C
C
C     NEX,NEG .
      SUBROUTINE NEG(LABEL,OPERAT,ADRES1,PCOUNT,NWORDS,
     $HEXM,BIN1,BIN2)
      COMMON/BLOCK1/NPASS
      CHARACTER*1 BIN1(16),BIN2(16),BIN32(32),HEXM(4)
      CHARACTER*1 MODE(3),REG(3),TYPE
      INTEGER FLG
      INTEGER*4 PCOUNT,NUM
      CHARACTER*9 ADRES1,DUMMY
      CHARACTER*6 LABEL,OPERAT
      DUMMY='$0000'
      IF(NPASS.NE.1)GO TO 100
         CALL LABTAB(LABEL,PCOUNT,NK)
         IF(ADRES1(1:1).EQ.'(')ADRES1='$0000'
         GO TO 150
 100  CALL LABAD(ADRES1,DUMMY)
 150  CALL DIGHEX(PCOUNT,HEXM)
      DO 200 J=1,16
         BIN1(J)='0'
 200  CONTINUE
      IF(OPERAT(4:4).EQ.'B')GO TO 240
      IF(OPERAT(4:4).NE.'W')GO TO 210
         BIN1(7)='1'
         GO TO 240
210   IF(OPERAT(4:4).NE.'L')GO TO 220
         BIN1(8)='1'
         GO TO 240
220   WRITE(5,225)OPERAT
225   FORMAT(1X,'IMPROPER SIZE SPEC FOR  ',A6)
      STOP
240   CALL TADR(ADRES1,MODE,REG,NUM,TYPE,FLG)
      DO 250 J=1,3
         BIN1(J)=REG(J)
         BIN1(J+3)=MODE(J)
250   CONTINUE
      NWORDS=1
      PCOUNT=PCOUNT+2
      CALL NUMBIN(NUM,BIN32,BIN2,NZ)
260   BIN1(15)='1'
      IF(OPERAT(1:3).EQ.'NEG')BIN1(11)='1'
      RETURN
      END


      SWAP
      SUBROUTINE SWAP(LABEL,OPERAT,ADRES1,PCOUNT,NWORDS,
     $HEXM,BIN1)
      COMMON/BLOCK1/NPASS
      CHARACTER*1 MODE(3),REG(3),HEXM(4),BIN1(16)
      CHARACTER*1 BIN32(32),TYPE
      INTEGER FLG
      INTEGER*4 PCOUNT,NUM
      CHARACTER*6 LABEL,OPERAT
      CHARACTER*9 ADRES1
      IF(ADRES1(1:1).NE.'D')GO TO 60
      IF(NPASS.NE.1)GO TO 20
         CALL LABTAB(LABEL,PCOUNT,NA)
20    CALL DIGHEX(PCOUNT,HEXM)
      DO 30 J=1,16
         BIN1(J)='0'
30    CONTINUE
      BIN1(15)='1'
      BIN1(12)='1'
      BIN1(7)='1'
      CALL TADR(ADRES1,MODE,REG,NUM,TYPE,FLG)
      DO 40 J=1,3
         BIN1(J)=REG(J)
40    CONTINUE
      PCOUNT=PCOUNT+2
      NWORDS=1
      RETURN
60    WRITE(5,70)OPERAT
70    FORMAT(1X,'IMPROPER ADDRESS FOR  ',A6)
      END
```

UTLSUB.FTN

```
C       SEPARATES STRING INTO ARRAY
        SUBROUTINE KSTRIN(SOLID,SEP)
        CHARACTER*4 SOLID
        CHARACTER*1 SEP(4)
        DO 100 J=1,4
           K=5-J
           SEP(J)=SOLID(K:K)
 100    CONTINUE
        RETURN
        END
C
C       16 OR 32 BIT TWO'S COMPLIMENT
        SUBROUTINE TCOMP(BIN16,BIN32,NF)
        CHARACTER*1 BIN16(16),BIN32(32)
        INTEGER NF
        IF(NF,NE,0)GO TO 100
           DO 50 K=1,16
              IF(BIN16(K),EQ,'0')GO TO 40
                BIN16(K)='0'
                GO TO 50
 40           BIN16(K)='1'
 50        CONTINUE
           DO 75 K=1,16
              IF(BIN16(K),NE,'0')GO TO 60
                BIN16(K)='1'
                GO TO 90
 60           BIN16(K)='0'
 75        CONTINUE
 90        GO TO 200
 100    DO 150 K=1,32
           IF(BIN32(K).EQ,'0')GO TO 140
              BIN32(K)='0'
              GO TO 150
 140       BIN32(K)='1'
 150    CONTINUE
        DO 175 K=1,32
           IF(BIN32(K).NE,'0')GO TO 160
              BIN32(K)='1'
              GO TO 200
 160       BIN32(K)='0'
 175    CONTINUE
 200    RETURN
        END
C
C       16 OR 32 BIT ONE'S COMPLIMENT
        SUBROUTINE OCOMP(BIN16,BIN32,NF)
        CHARACTER*1 BIN16(16),BIN32(32)
        INTEGER NF
        IF(NF,NE,0)GO TO 100
           DO 50 K=1,16
              IF(BIN16(K),EQ,'0')GO TO 40
                BIN16(K)='0'
                GO TO 50
 40           BIN16(K)='1'
 50        CONTINUE
        GO TO 200
 100    DO 150 K=1,32
           IF(BIN32(K).EQ,'0')GO TO 140
              BIN32(K)='0'
              GO TO 150
 140       BIN32(K)='1'
 150    CONTINUE
 200    RETURN
```

```
      END
C
C     CHECKSUM SUBROUTINE
      SUBROUTINE CKSUM(SREC,LENGTH)
      COMMON/BLOCK1/NPASS
      COMMON/BLOKK2/LABEL,OPERAT,ADRES1,ADRES2
      INTEGER LENGTH,NZ,D,NPASS
      CHARACTER*1 SREC(30),HEX(4),BIN16(16),BIN32(32),SPEC(30)
      CHARACTER*6 LABEL,OPERAT
      CHARACTER*9 ADRES1,ADRES2
      INTEGER*4 SUM,NUM,CSUM
      HEX(4)='0'
      HEX(3)='0'
      SUM=0
      N=2
      IF(LENGTH.EQ.0)NZ=4
      IF(LENGTH.EQ.1)NZ=5
      IF(LENGTH.EQ.2)NZ=7
      IF(LENGTH.EQ.3)NZ=9
      DO 100 J=1,NZ
         HEX(2)=SREC(N+1)
         HEX(1)=SREC(N+2)
         CALL HEXNUM(HEX,NUM)
         SUM=SUM+NUM
         N=N+2
 100  CONTINUE
      CALL NUMBIN(SUM,BIN32,BIN16,D)
      CALL OCOMP(BIN16,BIN32,0)
      CALL BINDIG(BIN16,CSUM)
      CALL DIGHEX(CSUM,HEX)
      SREC(N+1)=HEX(2)
      SREC(N+2)=HEX(1)
      IF(NPASS.NE.2)GO TO 200
         DO 110 JK=1,25
            SPEC(JK)=SREC(JK)
 110     CONTINUE
         SPEC(N+1)=' '
         SPEC(N+2)=' '
         WRITE(11,120)LABEL,OPERAT,ADRES1,ADRES2,(SPEC(JZ),JZ=5,20)
 120     FORMAT(1X,A6,T9,A6,T17,A9,T28,A9,T40,4A1,T50,2A1,1X,2A1,
     $1X,2A1,1X,2A1,1X,2A1,1X,2A1)
 200  RETURN
      END
C
C     LABEL/LOCATION
      SUBROUTINE LABTAB(LABEL,PLACE,NK)
      CHARACTER*6 LABEL,LARRY(100)
      INTEGER*4 PLACE,LOCAT(100)
      COMMON/BLOCK1/NPASS
      IF(LABEL.EQ.'XSTART')N=1
      IF(NPASS.EQ.2)GO TO 100
         LARRY(N)=LABEL
         LOCAT(N)=PLACE
         N=N+1
         GO TO 200
 100  DO 150 K=1,100
         IF(LABEL.NE.LARRY(K))GO TO 150
            PLACE=LOCAT(K)
            GO TO 200
 150  CONTINUE
 200  RETURN
      END
C
C     LABEL/ADRESS SUBROUTINE
      SUBROUTINE LABAD(ADRES1,ADRES2)
      CHARACTER*1 HEX(4),HEX2(4)
      INTEGER*4 PLACE,PLACE2
      CHARACTER*9 ADRES1,ADRES2
      IF(ADRES1(1:1).NE.'(')GO TO 110
         CALL LABTAB(ADRES1(2:),PLACE,NK)
         CALL DIGHEX(PLACE,HEX)
         OPEN(UNIT=2,FILE='TMP.DAT',STATUS='NEW')
         WRITE(2,120)(HEX(J),J=4,1,-1)
120      FORMAT(1X,'$',4A1)
         REWIND 2
         CLOSE (UNIT=2,STATUS='KEEP')
         OPEN (UNIT=2,FILE='TMP.DAT',STATUS='OLD')
         READ(2,130)ADRES1
130      FORMAT(T2,A9)
         CLOSE(UNIT=2,STATUS='DELETE')
110   IF(ADRES2(1:1).NE.'(')GO TO 140
         CALL LABTAB(ADRES2(2:),PLACE2,NK)
         CALL DIGHEX(PLACE2,HEX2)
         OPEN(UNIT=2,FILE='TCP.DAT',STATUS='NEW')
         WRITE(2,135)(HEX2(J),J=4,1,-1)
         REWIND 2
135      FORMAT(1X,'$',4A1)
         REWIND 2
         READ(2,138)ADRES2
138      FORMAT(T2,A9)
         CLOSE(UNIT=2,STATUS='DELETE')
140   RETURN
      END

C     BTST - BIT TEST
      SUBROUTINE TEST(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,NWORDS,
     $HEXM,BIN1,BIN2,BIN3)
      COMMON/BLOCK1/NPASS
      CHARACTER*1 BIN1(16),BIN2(16),BIN32(32),HEXM(4)
      CHARACTER*1 MODE(3),REG(3),TYPE
      CHARACTER*6 LABEL,OPERAT
      CHARACTER*9 ADRES1,ADRES2
      INTEGER*4 PCOUNT,NUM
      INTEGER FLG
      IF(NPASS.NE.1)GO TO 20
         CALL LABTAB(LABEL,PCOUNT,NA)
         IF(ADRES2(1:1).EQ.'(')ADRES2='$0000'
         GO TO 30
20    CALL LABAD(ADRES1,ADRES2)
30    CALL DIGHEX(PCOUNT,HEXM)
      DO 40 J=1,16
         BIN1(J)='0'
40    CONTINUE
      BIN1(12)='1'
      CALL TADR(ADRES1,MODE,REG,NUM,TYPE,FLG)
      CALL NUMBIN(NUM,BIN32,BIN2,NZ)
      NWORDS=2
      CALL TADR(ADRES2,MODE,REG,NUM,TYPE,FLG)
      DO 50 J=1,3
         BIN1(J)=REG(J)
         BIN1(J+3)=MODE(J)
50    CONTINUE
      PCOUNT=PCOUNT+4
      IF(FLG.NE.1)GO TO 70
         NWORDS=3
         PCOUNT=PCOUNT+2
         CALL NUMBIN(NUM,BIN32,BIN3,NZ)
70    RETURN
      END
```

OPTSUB2.FTN

```
C       OPERATION CODE SUBROUTINES
C
C       ADD,AND,ORR,CMP,SUB
C
        SUBROUTINE ANDADD(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,NWORDS,
     &HEXM,BIN1,BIN2)
        COMMON/BLOCK1/NPASS
        CHARACTER*1 BIN1(16),BIN2(16),HEXM(4),SD,BIN32(32)
        CHARACTER*1 REG1(3),REG2(3),MODE1(3),MODE2(3),TYPE
        INTEGER NWORDS,FLG1,FLG2
        INTEGER*4 PCOUNT,NUM1,NUM2
        CHARACTER*9 ADRES1,ADRES2
        CHARACTER*6 LABEL,OPERAT
C
        IF(NPASS.NE.1)GO TO 100
           CALL LABTAB(LABEL,PCOUNT,NA)
           IF(ADRES1(1:1).EQ.'(')ADRES1='$0000'
           IF(ADRES2(1:1).EQ.'(')ADRES2='$0000'
           GO TO 150
 100    CALL LABAD(ADRES1,ADRES2)
 150    CALL DIGHEX(PCOUNT,HEXM)
C
        IF(OPERAT(4:4).EQ.'1')BIN1(9)='0'
        IF(OPERAT(4:4).EQ.'2')BIN1(9)='1'
        IF(OPERAT(5:5).NE.'B')GO TO 160
           BIN1(7)='0'
           BIN1(8)='0'
           GO TO 170
 160    IF(OPERAT(5:5).NE.'L')GO TO 165
           BIN1(7)='0'
           BIN1(8)='1'
           GO TO 170
 165    IF(OPERAT(5:5).NE.'W')GO TO 167
           BIN1(7)='1'
           BIN1(8)='0'
           GO TO 170
 167    WRITE(5,169)OPERAT
 169    FORMAT(1X,'IMPROPER SIZE SPEC IN : ',A6,' INSTRUCTION')
        STOP
 170    CALL TADR(ADRES1,MODE1,REG1,NUM1,TYPE,FLG1)
        CALL TADR(ADRES2,MODE2,REG2,NUM2,TYPE,FLG2)
        IF(BIN1(9).NE.'0')GO TO 200
           DO 180 J=1,3
              BIN1(J)=REG1(J)
              BIN1(J+3)=MODE1(J)
 180       CONTINUE
        IF(FLG1.NE.1)GO TO 190
           NWORDS=2
           PCOUNT=PCOUNT+4
           CALL NUMBIN(NUM1,BIN32,BIN2,NZ)
           GO TO 195
 190    NWORDS=1
        PCOUNT=PCOUNT+2
 195    DO 199 J=1,3
           BIN1(J+9)=REG2(J)
 199    CONTINUE
        GO TO 250
 200    DO 210 J=1,3
           BIN1(J)=REG2(J)
           BIN1(J+3)=MODE2(J)
 210    CONTINUE
        IF(FLG2.NE.1)GO TO 215
```

```
         NWORDS=2
         PCOUNT=PCOUNT+4
         CALL NUMBIN(NUM2,BIN32,BIN2,NZ)
         GO TO 225
 215  NWORDS=1
      PCOUNT=PCOUNT+2
 225  DO 229 J=1,3
      BIN1(J+9)=REG1(J)
 229  CONTINUE
 250  BIN1(13)='1'
      BIN1(14)='0'
      BIN1(15)='1'
      BIN1(16)='1'
C
      IF(OPERAT(2:2).EQ.'N')BIN1(13)='0'
C
      IF(OPERAT(2:2).NE.'U')GO TO 700
         BIN1(15)='0'
         GO TO 900
C
 700  IF(OPERAT(3:3).NE.'R')GO TO 800
         BIN1(13)='0'
         BIN1(15)='0'
         GO TO 900
 800  IF(OPERAT(3:3).NE.'P')GO TO 850
         BIN1(14)='1'
         BIN1(15)='0'
         GO TO 900
 850  CONTINUE
 900  RETURN
      END
C
C
C     MOVE COMMAND
      SUBROUTINE MOVE(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,NWORDS,HEXM,
     &BIN1,BIN2,BIN3)
      COMMON/BLOCK1/NPASS
      CHARACTER*1 BIN1(16),BIN2(16),BIN3(16),BIN32(32),HEXM(4)
      CHARACTER*1 TYPE,REG1(3),REG2(3),MODE1(3),MODE2(3)
      INTEGER NWORDS,FLG1,FLG2
      INTEGER*4 PCOUNT,NUM1,NUM2,NTRAC
      CHARACTER*9 ADRES1,ADRES2
      CHARACTER*6 LABEL,OPERAT
      IF(NPASS.NE.1)GO TO 100
         CALL LABTAB(LABEL,PCOUNT,NK)
         IF(ADRES1(1:1).EQ.'(')ADRES1='$0000'
         IF(ADRES2(1:1).EQ.'(')ADRES2='$0000'
         GO TO 150
 100  CALL LABAD(ADRES1,ADRES2)
 150  CALL DIGHEX(PCOUNT,HEXM)
      IF(OPERAT(5:5).NE.'B')GO TO 160
         BIN1(13)='1'
         BIN1(14)='0'
         GO TO 170
 160  IF(OPERAT(5:5).NE.'L')GO TO 165
         BIN1(13)='0'
         BIN1(14)='1'
         GO TO 170
 165  IF(OPERAT(5:5).NE.'W')GO TO 167
         BIN1(13)='1'
         BIN1(14)='1'
         GO TO 170
 167  WRITE(5,169)OPERAT
 169  FORMAT(1X,'IMPROPER SIZEB SPEC IN  :',A6,' INSTRUCTION')
      STOP
 170  BIN1(15)='0'
```

```
      BIN1(16)='0'
      CALL TADR(ADRES1,MODE1,REG1,NUM1,TYPE,FLG1)
      CALL TADR(ADRES2,MODE2,REG2,NUM2,TYPE,FLG2)
      DO 175 J=1,3
         BIN1(J)=REG1(J)
         BIN1(J+3)=MODE1(J)
         BIN1(J+6)=MODE2(J)
         BIN1(J+9)=REG2(J)
 175  CONTINUE
      IF(FLG1.NE.1)GO TO 200
         NTRAC=4
         NWORDS=2
         CALL NUMBIN(NUM1,BIN32,BIN2,NZ)
         GO TO 210
 200  NTRAC=2
      NWORDS=1
 210  IF(FLG2.NE.1)GO TO 250
         NTRAC=NTRAC+2
         NWORDS=NWORDS+1
         IF(NWORDS.EQ.3)GO TO 240
            CALL NUMBIN(NUM2,BIN32,BIN2,NZ)
            GO TO 250
 240  CALL NUMBIN(NUM2,BIN32,BIN3,NZ)
 250  PCOUNT=PCOUNT+NTRAC
      RETURN
      END
C
C
      SUBROUTINE CMP(OPERAT)
      CHARACTER*6 OPERAT
      IF(OPERAT(4:4).NE.'B')GO TO 50
         OPERAT='CMP1B'
         GO TO 100
 50   IF(OPERAT(4:4).NE.'L')GO TO 60
         OPERAT='CMP1L'
         GO TO 100
 60   OPERAT='CMP1W'
 100  RETURN
      END
C
C
C     EOR (BIARY CODE SIMILAR TO CMP)
      SUBROUTINE EOR(OPERAT)
      CHARACTER*6 OPERAT
      IF(OPERAT(4:4).NE.'B')GO TO 50
          OPERAT='CMP2B'
          GO TO 100
 50   IF(OPERAT(4:4).NE.'L')GO TO 60
          OPERAT='CMP2L'
          GO TO 100
 60   OPERAT='CMP2W'
 100  RETURN
      END
C     ARITH, SHIFT LEFT , RIGHT / LOGICAL SHIFTS
      SUBROUTINE AS(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,NWORDS,
     $HEXM,BIN1,BIN2)
      COMMON/BLOCK1/NPASS
      CHARACTER*1 HEXM(4),BIN1(16),BIN2(16),BIN32(32)
      CHARACTER*1 TYPE,MODE(3),REG(3)
      CHARACTER*6 LABEL,OPERAT
      CHARACTER*9 ADRES1,ADRES2
      INTEGER*4 PCOUNT,NUM
      INTEGER NWORDS,FLG
C
      IF(NPASS.NE.1)GO TO 20
         CALL LABTAB(LABEL,PCOUNT,NK)
         IF(ADRES1(1:1).EQ.'(')ADRES1='$0000'
         IF(ADRES2(1:1).EQ.'(')ADRES2='$0000'
         GO TO 30
 20   CALL LABAD(ADRES1,ADRES2)
 30   CALL DIGHEX(PCOUNT,HEXM)
C
      IF(OPERAT(5:5).NE.'B')GO TO 50
         BIN1(7)='0'
         BIN1(8)='0'
         GO TO 100
 50   IF(OPERAT(5:5).NE.'L')GO TO 70
         BIN1(7)='0'
         BIN1(8)='1'
         GO TO 100
 70   BIN1(7)='1'
      BIN1(8)='0'
 100  IF(OPERAT(3:3).EQ.'L')BIN1(9)='1'
      IF(OPERAT(3:3).EQ.'R')BIN1(9)='0'
      BIN1(13)='0'
      BIN1(14)='1'
      BIN1(15)='1'
      BIN1(16)='1'
      IF(OPERAT(4:4).EQ.'M')GO TO 200
         BIN1(6)='1'
         IF(ADRES1(1:1).NE.'D')GO TO 800
         IF(ADRES2(1:1).NE.'D')GO TO 800
         CALL TADR(ADRES1,MODE,REG,NUM,TYPE,FLG)
         DO 120 J=1,3
            BIN1(J+9)=REG(J)
 120     CONTINUE
         CALL TADR(ADRES2,MODE,REG,NUM,TYPE,FLG)
         DO 130 J=1,3
            BIN1(J)=REG(J)
 130     CONTINUE
         BIN1(4)='0'
         BIN1(5)='0'
         IF(OPERAT(1:1).NE.'R')GO TO 135
            BIN1(4)='1'
            BIN1(5)='1'
 135      CONTINUE
         NWORDS=1
         PCOUNT=PCOUNT+2
         IF(OPERAT(1:1).EQ.'L')BIN1(4)='1'
         GO TO 700
 200  DO 210 J=1,3
         BIN1(J+9)='0'
 210  CONTINUE
      BIN1(7)='1'
      BIN1(8)='1'
      IF(OPERAT(1:1).EQ.'L')BIN1(10)='1'
      IF(OPERAT(1:1).NE.'R')GO TO 215
          BIN1(10)='0'
          BIN1(11)='0'
 215  CONTINUE
      CALL TADR(ADRES1,MODE,REG,NUM,TYPE,FLG)
      DO 220 J=1,3
         BIN1(J)=REG(J)
         BIN1(J+3)=MODE(J)
 220  CONTINUE
      NWORDS=1
      PCOUNT=PCOUNT+2
      IF(FLG.EQ.0)GO TO 700
         CALL NUMBIN(NUM,BIN32,BIN2,NZ)
         NWORDS=2
         PCOUNT=PCOUNT+2
 700  RETURN
```

```
  800    WRITE(5,850)OPERAT
  850    FORMAT(1X,'IMPROPER ADDRESSING MODE FOR : ',A4)
         STOP
         END
C
C        CONDITIONAL BRANCH/ UNCONDITIONAL BRANCH
         SUBROUTINE BCC(LABEL,OPERAT,ADRES1,PCOUNT,NWORDS,HEXM,
     $BIN1,BIN2)
         COMMON/BLOCK1/NPASS
         CHARACTER*1 HEXM(4),BIN1(16),BIN2(16),BIN32(32),TYPE
         CHARACTER*1 REG(3),MODE(3)
         CHARACTER*6 LABEL,OPERAT
         CHARACTER*9 ADRES1,DUMMY
         INTEGER*4 PCOUNT,NUM,RESULT,NUM2,ABSRES
         INTEGER NWORDS,NPASS,FLG
         DUMMY='$0000'
C
         IF(NPASS.NE.1)GO TO 20
            CALL LABTAB(LABEL,PCOUNT,NK)
            IF(ADRES1(1:1).EQ.'(')ADRES1='$0000'
            GO TO 30
   20    CALL LABAD(ADRES1,DUMMY)
   30    CALL DIGHEX(PCOUNT,HEXM)
         DO 50 J=1,13
            BIN1(J)='0'
   50    CONTINUE
         BIN1(14)='1'
         BIN1(15)='1'
         BIN1(16)='0'
         IF(OPERAT(2:3).NE.'RA')GO TO 60
            GO TO 88
   60    IF(OPERAT(2:3).NE.'HI')GO TO 62
            BIN1(10)='1'
            GO TO 88
   62    IF(OPERAT(2:3).NE.'LS')GO TO 64
            BIN1(10)='1'
            BIN1(9)='1'
            GO TO 88
   64    IF(OPERAT(2:3).NE.'SR')GO TO 66
            BIN1(9)='1'
            GO TO 88
   66    IF(OPERAT(2:3).NE.'CC')GO TO 68
            BIN1(11)='1'
            GO TO 88
   68    IF(OPERAT(2:3).NE.'CS')GO TO 70
            BIN1(11)='1'
            BIN1(9)='1'
            GO TO 88
   70    IF(OPERAT(2:3).NE.'NE')GO TO 72
            BIN1(10)='1'
            BIN1(11)='1'
            GO TO 88
   72    IF(OPERAT(2:3).NE.'VC')GO TO 74
            BIN1(12)='1'
            GO TO 88
   74    IF(OPERAT(2:3).NE.'VS')GO TO 76
            BIN1(9)='1'
            BIN1(12)='1'
            GO TO 88
   76    DO 77 J=1,4
            BIN1(J+8)='1'
   77    CONTINUE
   79    IF(OPERAT(2:3).NE.'EQ')GO TO 80
            BIN1(12)='0'
            GO TO 88
   80    IF(OPERAT(2:3).NE.'PL')GO TO 81
```

```
           BIN1(9)='0'
           BIN1(11)='0'
           GO TO 88
 81     IF(OPERAT(2:3).NE.'MI')GO TO 82
           BIN1(11)='0'
           GO TO 88
 82     IF(OPERAT(2:3).NE.'GE')GO TO 83
           BIN1(9)='0'
           BIN1(10)='0'
           GO TO 88
 83     IF(OPERAT(2:3).NE.'LT')GO TO 84
           BIN1(10)='0'
           GO TO 88
 84     IF(OPERAT(2:3).NE.'GT')GO TO 85
           BIN1(9)='0'
           GO TO 88
 85     IF(OPERAT(2:3).EQ.'LE')GO TO 88
        WRITE(5,86)OPERAT
 86     FORMAT(1X,'IMPROPER BRANCH CONDITION :',A6)
        STOP
C
 88     IF(ADRES1(1:1).EQ.'S')GO TO 100
        IF(ADRES1(1:1).EQ.'P')GO TO 200
        WRITE(5,90)OPERAT
 90     FORMAT(1X,'INVALID ADDRESS FOR :',A6)
        STOP
C
 100    CALL TADR(ADRES1,MODE,REG,NUM,TYPE,FLG)
           RESULT=NUM-PCOUNT-2
           ABSRES=JIABS(RESULT)
           CALL NUMBIN(ABSRES,BIN32,BIN2,NF)
           IF(RESULT.GE.0)GO TO 150
              CALL TCOMP(BIN2,BIN32,NF)
 150       PCOUNT=PCOUNT+4
           NWORDS=2
           GO TO 300
 200    CALL TADR(ADRES1,MODE,REG,NUM,TYPE,FLG)
           CALL NUMBIN(NUM,BIN32,BIN2,NF)
           PCOUNT=PCOUNT+4
           NWORDS=2
 300    RETURN
        END

C
C
C       MOVEQ INSTRUCTION
        SUBROUTINE QMOVE(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,
     $NWORDS,HEXM,BIN1)
        COMMON/BLOCK1/NPASS
        CHARACTER*6 LABEL,OPERAT
        CHARACTER*9 ADRES1,ADRES2
        CHARACTER*1 BIN1(16),BIN32(32),HEXM(4),TYPE,BIN2(16)
        CHARACTER*1 REG1(3),REG2(3),MODE1(3),MODE2(3)
        INTEGER NWORDS,FLG
        INTEGER*4 PCOUNT,NUM1,NUM2
C
        IF(NPASS.NE.1)GO TO 100
           CALL LABTAB(LABEL,PCOUNT,K)
 100    CALL DIGHEX(PCOUNT,HEXM)
        IF(ADRES1(1:1).NE.'#')GO TO 200
        IF(ADRES2(1:1).NE.'D')GO TO 200
C
        CALL TADR(ADRES1,MODE1,REG1,NUM1,TYPE,FLG)
        CALL TADR(ADRES2,MODE2,REG2,NUM2,TYPE,FLG)
        BIN1(16)='0'
        BIN1(15)='1'
```

```
      BIN1(14)='1'
      BIN1(13)='1'
      BIN1(9)='0'
      DO 110 J=1,3
         BIN1(J+9)=REG2(J)
 110  CONTINUE
      CALL NUMBIN(NUM1,BIN32,BIN2,NF)
      DO 120 J=1,8
         BIN1(J)=BIN2(J)
 120  CONTINUE
      PCOUNT=PCOUNT+2
      NWORDS=1
      RETURN
 200  WRITE(5,210)
 210  FORMAT(1X,'IMPROPER ADDRESS FOR MOVEQ COMMAND')
      STOP
      END
C
C
C     ADDQ
      SUBROUTINE QADD(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,
     $NWORDS,HEXM,BIN1,BIN2)
      COMMON/BLOCK1/NPASS
      CHARACTER*6 LABEL,OPERAT
      CHARACTER*9 ADRES1,ADRES2
      CHARACTER*1 BIN1(16),BIN2(16),BIN32(32),HEXM(4)
      CHARACTER*1 TYPE,DAT(3),REG(3),MODE(3)
      INTEGER FLG
      INTEGER*4 PCOUNT,NUM
C
      DO 10 J=1,16
         BIN1(J)='0'
 10   CONTINUE
C
      IF(NPASS.NE.1)GO TO 20
         CALL LABTAB(LABEL,PCOUNT,NK)
         IF(ADRES2(1:1).EQ.'(')ADRES2='$0000'
         GO TO 30
 20   CALL LABAD(ADRES1,ADRES2)
 30   CALL DIGHEX(PCOUNT,HEXM)
C
      IF(ADRES1(1:1).NE.'#')GO TO 90
      DO 35 J=2,9
         M=J
         IF(ADRES1(J:J).NE.'0')GO TO 45
 35   CONTINUE
 45   IF(ADRES1(M:M).NE.'8')GO TO 50
         DO 48 J=1,3
            DAT(J)='0'
 48      CONTINUE
         GO TO 55
 50   CALL ADRLOC(ADRES1(M:M),DAT)
 55   CALL TADR(ADRES2,MODE,REG,NUM,TYPE,FLG)
C
      DO 60 J=1,3
         BIN1(J)=REG(J)
         BIN1(J+3)=MODE(J)
         BIN1(J+9)=DAT(J)
 60   CONTINUE
      BIN1(13)='1'
      BIN1(15)='1'
C
      IF(OPERAT(5:5).NE.'B')GO TO 70
         GO TO 95
 70   IF(OPERAT(5:5).NE.'L')GO TO 80
         BIN1(8)='1'
```

```
            GO TO 95
   80     IF(OPERAT(5:5).NE.'W')GO TO 90
             BIN1(7)='1'
             GO TO 95
   90     WRITE(5,100)OPERAT
   100    FORMAT(1X,'IMPROPER SIZE SPEC OR ADDRESSING MODE FOR :',A6)
          STOP
   95     NWORDS=1
          PCOUNT=PCOUNT+2
          IF(FLG.NE.1)GO TO 150
             CALL NUMBIN(NUM,BIN32,BIN2,NZ)
             NWORDS=2
             PCOUNT=PCOUNT+2
   150    RETURN
          END
C
C
C         IMMEDIATE ADD,AND,ORR,EOR
          SUBROUTINE IMME(LABEL,OPERAT,ADRES1,ADRES2,PCOUNT,
       $NWORDS,HEXM,BIN1,BIN2,BIN3)
          COMMON/BLOCK1/NPASS
          CHARACTER*6 LABEL,OPFRAT
          CHARACTER*9 ADRES1,ADRES2
          CHARACTER*1 BIN1(16),BIN2(16),BIN3(16),BIN32(32)
          CHARACTER*1 HEXM(4),REG(3),MODE(3),TYPE
          INTEGER FLG,NWORDS,NPASS
          INTEGER*4 PCOUNT,NUM1,NUM2
          IF(NPASS.NE.1)GO TO 20
             CALL LABTAB(LABEL,PCOUNT,NK)
             IF(ADRES2(1:1).EQ.'(')ADRES2='$0000'
             GO TO 30
   20     CALL LABAD(ADRES1,ADRES2)
   30     CALL DIGHEX(PCOUNT,HEXM)
          IF(ADRES1(1:1).NE.'#')GO TO 200
          DO 40 J=1,16
           BIN1(J)='0'
   40     CONTINUE
C
          IF(OPERAT(1:3).NE.'ORR')GO TO 45
             GO TO 100
   45     IF(OPERAT(1:3).NE.'EOR')GO TO 50
             BIN1(12)='1'
             BIN1(10)='1'
             GO TO 100
   50     IF(OPERAT(1:3).NE.'CMP')GO TO 60
             BIN1(11)='1'
             BIN1(12)='1'
             GO TO 100
   60     IF(OPERAT(1:3).NE.'AND')GO TO 70
             BIN1(10)='1'
             GO TO 100
   70     IF(OPERAT(1:3).NE.'ADD')GO TO 75
             BIN1(10)='1'
             BIN1(11)='1'
             GO TO 100
   75     IF(OPERAT(1:3).NE.'SUB')GO TO 80
             BIN1(11)='1'
             GO TO 100
   80     WRITE(5,90)OPERAT
   90     FORMAT(1X,'UNRECOGNIZED COMMAND :',A6)
          STOP
   100    NWORDS=2
          PCOUNT=PCOUNT+4
          IF(OPERAT(5:5).NE.'B')GO TO 110
             GO TO 135
   110    IF(OPERAT(5:5).NE.'W')GO TO 200
```

```
         BIN1(7)='1'
 35      CALL TADR(ADRES1,MODE,REG,NUM1,TYPE,FLG)
         CALL TADR(ADRES2,MODE,REG,NUM2,TYPE,FLG)
         CALL NUMBIN(NUM1,BIN32,BIN2,NZ)
         DO 140 J=1,3
            BIN1(J)=REG(J)
            BIN1(J+3)=MODE(J)
 40      CONTINUE
         IF(FLG.EQ.0)GO TO 160
            CALL NUMBIN(NUM2,BIN32,BIN3,NZ)
            NWORDS=3
            PCOUNT=PCOUNT+2
 60      RETURN
 00      WRITE(5,210)OPERAT
 10      FORMAT(' IMPROPER SIZE SPEC OR ADDRESSING MODE FOR :',A6)
         STOP
         END
```

APPENDIX B

Bibliography

Kane, Hawkins, Leventhal, 68000 Assembly Language Programming McGraw-Hill, Berkely, California, 1981.

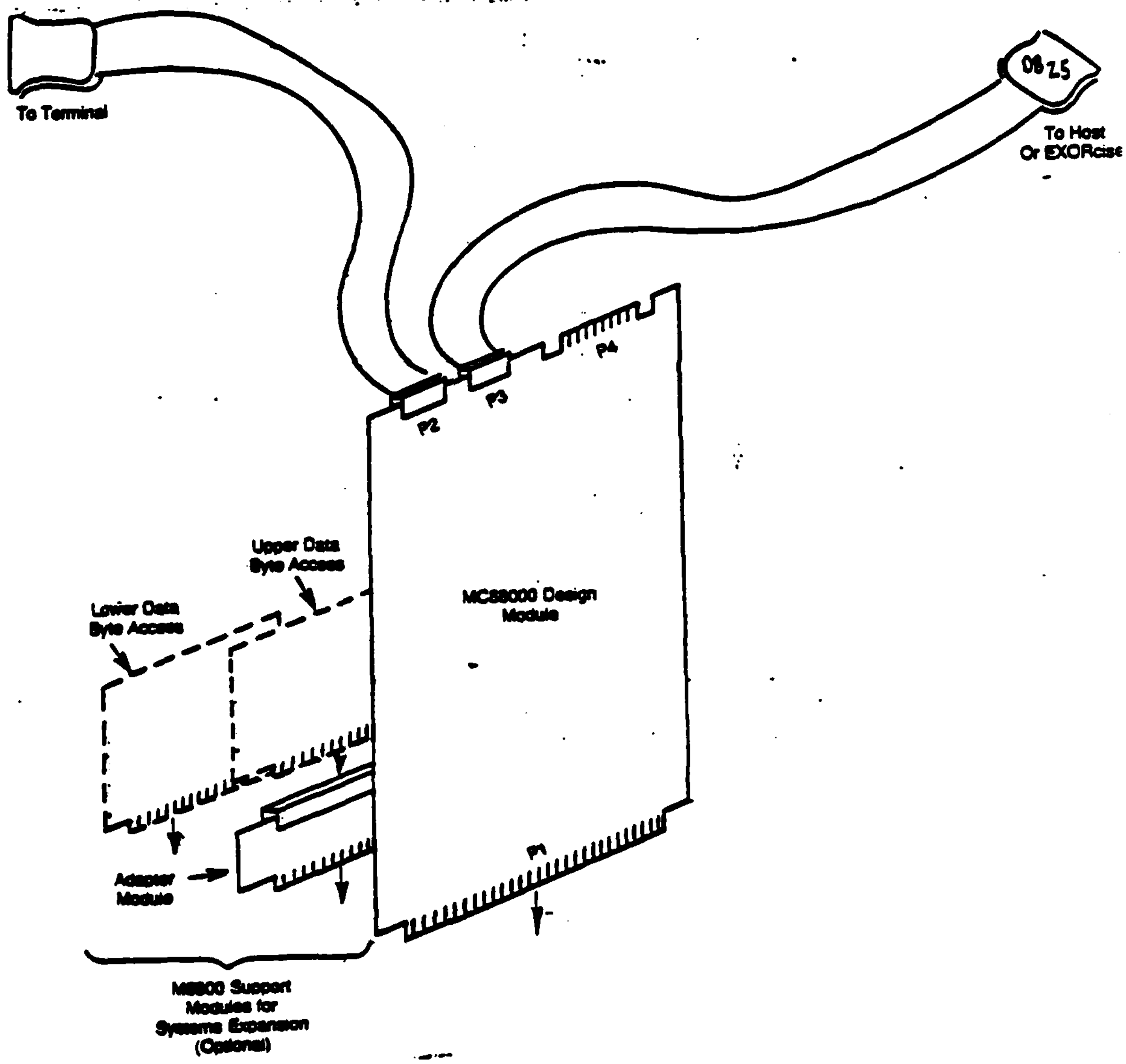
Motorola Inc., MC68000 Design Module Users Guide (MEX68KDM), 1980.

APPENDIX C

the MC68000 Design Module and its associated connectors.

Connection to DEC 11/45:

P3 PIN		DB25 PIN
1	↔	1
3	↔	3
5	↔	2
13	↔	7
9↔14		
		4↔20



MC68000 Design Module

Diagram from: MC68000 Design Module USERS GUIDE (MEX68KDM(D2)), pg. 2-6

APPENDIX D

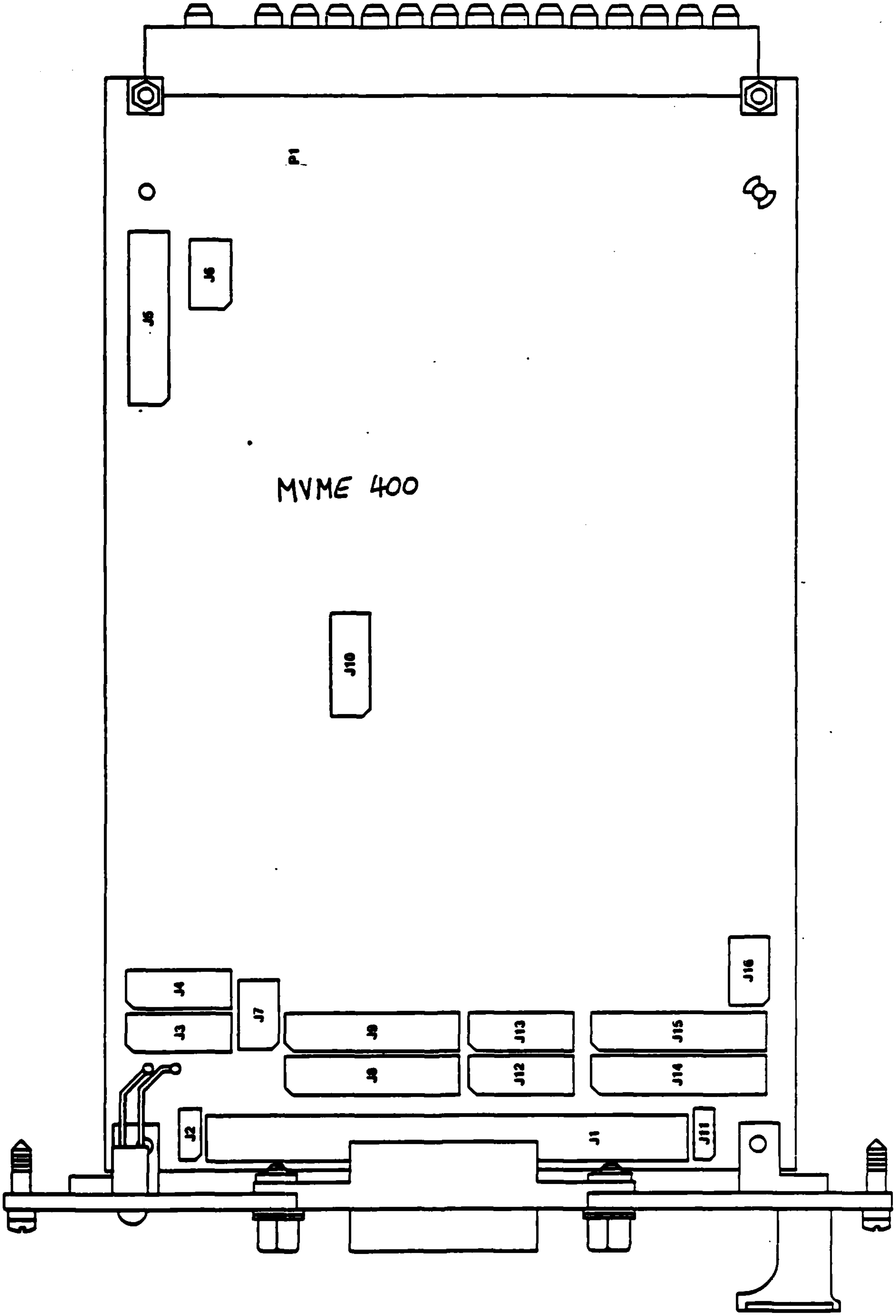
DSP RS-232C Connector Pin Assignments*

FRONT PANEL			
PORTS 1 & 2	MODULE J1	SIGNAL	
PIN NUMBER	PIN NUMBER	MNEMONIC	SIGNAL NAME AND DESCRIPTION
2	3,28	TxD	TRANSMITTED DATA - Serial binary data output.
3	5,30	RxD	RECEIVED DATA - Serial binary data input.
4	7,32	RTS	REQUEST TO SEND - A signal denoting terminal has data to send.
5	9,34	CTS	CLEAR TO SEND - A signal that indicates the terminal can transmit data.
6	11,36	DSR	DATA SET READY - A signal denoting the modem is ready (off the hook).
7	13,38	SIG GND	SIGNAL GROUND
8	15,40	DCD	DATA CARRIER DETECT - A signal that indicates to the terminal that a carrier is present.
15	4,29	TxC	TRANSMITTER CLOCK - (DCE Source) A signal that provides timing information for transmitted data.
17	8,33	RxC	RECEIVER CLOCK - A signal that provides timing information for received data.
20	14,39	DTR	DATA TERMINAL READY - A signal that denotes the terminal is ready to transmit or receive data.
22	18,43	RI	RING INDICATOR - A signal to DTE that denotes the modem is receiving a ringing signal.
24	22,47	TxC	TRANSMITTER CLOCK - (DTE Source) A signal that provides timing information for transmitted data.

* Chart from: MVME400 Dual RS-232C Serial Port Module User's Manual (MVME400/02), p. 5-4

MVME400 INTERNAL JUMPERS *

HEADER	FUNCTION	JUMPER CONFIGURATION
J2	Port 2 TxC select	1-2
J3	Port 2 external clock select	No jumpers
J4	Port 2 internal clock select	1-2, 3-4, 9-10, 11-12
J5	Interrupt level select	3-5, 9-11, 15-17
J6	Base address select	7-8
J7	Port 2 CTS flow control	5-7, 6-8
J8	Port 2 to modem select	13-14
J9	Port 2 to terminal select	1-2, 3-4, 5-6, 7-8, 9-10, 11-12, 13-14, 15-16, 17-18, 19-20
J10	Baud rate port 1 and 2 select	3-4, 5-6,9-10, 11-12
J11	Port 1 TxC select	1-2
J12	Port 1 external clock select	No jumpers
J13	Port 1 internal clock select	1-2, 3-4, 9-10, 11-12
J14	Port 1 to modem select	13-14
J15	Port 1 to terminal select	1-2, 3-4, 5-6, 7-8, 9-10, 11-12, 13-14, 15-16, 17-18, 19-20
J16	Port 1 CTS flow control	5-7, 6-8



DSP Module Header Location Diagram

MVME400/D2, P 5-4

D3

Compiling the Cross-assembler on the Host System:

The cross-assembler and its subroutinesfT

SUBS2.FTN
SUBS3.FTN
DCSUB.FTN
MC68CRX.FTN

These must be compiled in FORTRAN 77 prior to taskbuilding.

Taskbuilding:

After compiling, the subroutines and main program must be taskbuilt or linked. On the DEC PDP11/45 with the RSX-11 operating system, the following taskbuilding session may be used:

```
TKB
MC68CRX/CP/FP=MC68CRX,DCSUB,SUBDIR,UTLSUB,SUBS1,SUBS2,
SUBS3,OPTSUB2
/
UNITS=12
ACTFIL=6
ASG=SY0:2:3:4:11,TI0:5
//
```

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